REPORT OF THE BOTANICAL DEPT

Report of the Botanical Dept

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REPORT

OF THE

BOTANICAL DEPARTMENT

OF THE

New Jersey Agricultural College Experiment Station,

BY

BYRON D. HALSTED, Sc.D.,

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REPORT OF THE BOTANIST.

The work in the Botanical Department for the year ending November 30th, 1896, has been mainly with field experiments at the College Farm and elsewhere in the State, supplemented with investigations in the laboratory.

The experiment acre of the past two years has been extended so that nearly two acres are included, and is now known as the Experiment Area.

The chief lines of work have been with fungicides upon the various truck crops, namely, turnips, potatoes, beans, tomatoes, peppers, egg-plants, cucumbers, celery, beets, peas, sweet potatoes and a few kinds of ornamental plants.

Experiments with sweet potatoes have been made upon four separate fields in the State, all of which again point to sulphur as an efficient remedy for the soil rot.

A study of the peach gall has been a leading feature of the work in the greenhouse.

The herbarium has been enlarged by a few hundred specimens, and the index of the host plants now includes all of the more than 20,000 specimens.

Some work has been done with weeds and a new device for detecting foul stuff in commercial seeds constructed.

Since the last report was issued, Bulletin No. 115, "Irrigation of Garden Crops," has been published.

Mr. James A. Kelsey, as field assistant, has had charge of the details of the experiments at the College Farm, and has aided greatly in the preparation of this Report.

THE EXPERIMENT AREA.

In 1894, five crops were experimented upon, namely, turnips, cabbages, tomatoes, potatoes and beans. In 1895, this list was modified somewhat by discarding cabbages, because turnips answered all the purposes for tests of fungicides for the club-root common to these two crops, and in adding to the list the following crops, namely, peppers, egg-plants, cucumbers and celery. In land adjoining to the acre privileges were granted for experiments upon beets and carrots, and therefore quite a full list of the truck crops of the State was represented. Upon the three succeeding pages are diagrams (Figures 1, 2 and 3) showing the plans of the Experiment Area for the years 1894, 1895 and 1896.

In 1894, each of the five crops occupied the same amount of space; that is, each had a series divided into four plots, as shown in Figure 1* The crops in 1895 were disposed as shown in Figure 2. It will be seen that the turnips were upon the old ground, the potatoes upon the series bearing cabbages last year; tomatoes occupied two of the old plots, while the other two were devoted to peppers. Upon the potato ground of 1894 (Plots I. and II.) were beans for the first crop, followed by celery, while the two other (lower) plots were given to egg-plants. The two upper plots of Series V. were again planted to beans, and upon the remaining two was grown a crop of cucumbers. To the left hand of the experiment acre and adjoining it was the beet-field, and to the right the area occupied by carrots.

The crops the present season (1896) were arranged as shown in Figure 3. Turnips remained upon the old ground where they have been for three years. Potatoes followed potatoes in Series II. In Series III. peppers followed peppers upon Plot I., while Plot II. was in potatoes (Rural No. 2); tomatoes followed tomatoes as a third crop upon Plot III., and beans were introduced for the first time upon Plot IV. In Series IV. turnips were introduced upon Plot I. after potatoes, beans and celery of former years; potatoes (Early Rose)

*The series are separated from each other by four-foot paths, and the plots in each series by two-foot spaces. Each plot is 33 x 66 feet, and is divided crosswise into six belts, each 11 x 33 feet. Each plot is one-twentieth and each belt one one-hundred and twentieth of an acre. This arrangement of the plots is given in detail in the report for 1894, page 278.

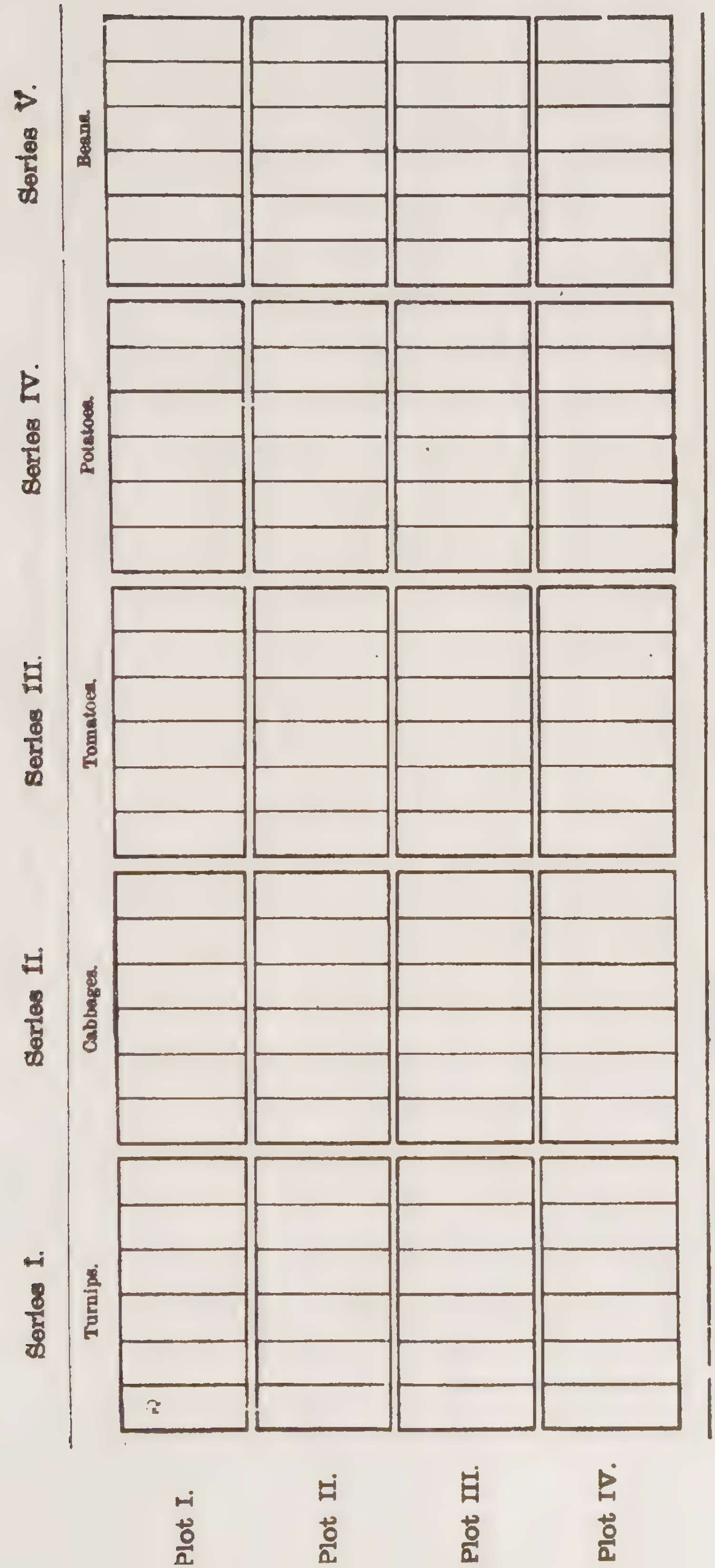

Fig. 1.
The Plan of the Experiment Acre for 1894.

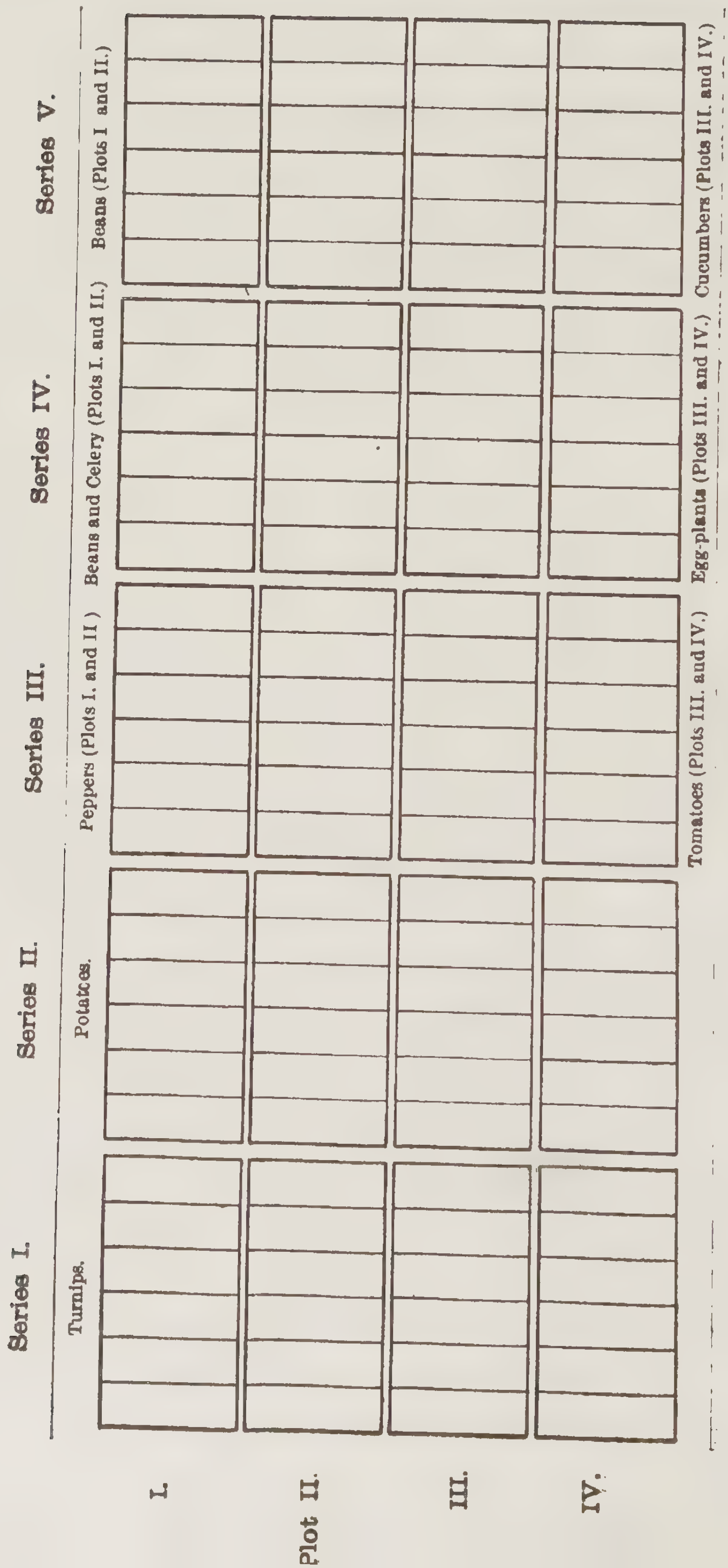

Fig. 2.
The Plan of the Experiment Acre for 1895.

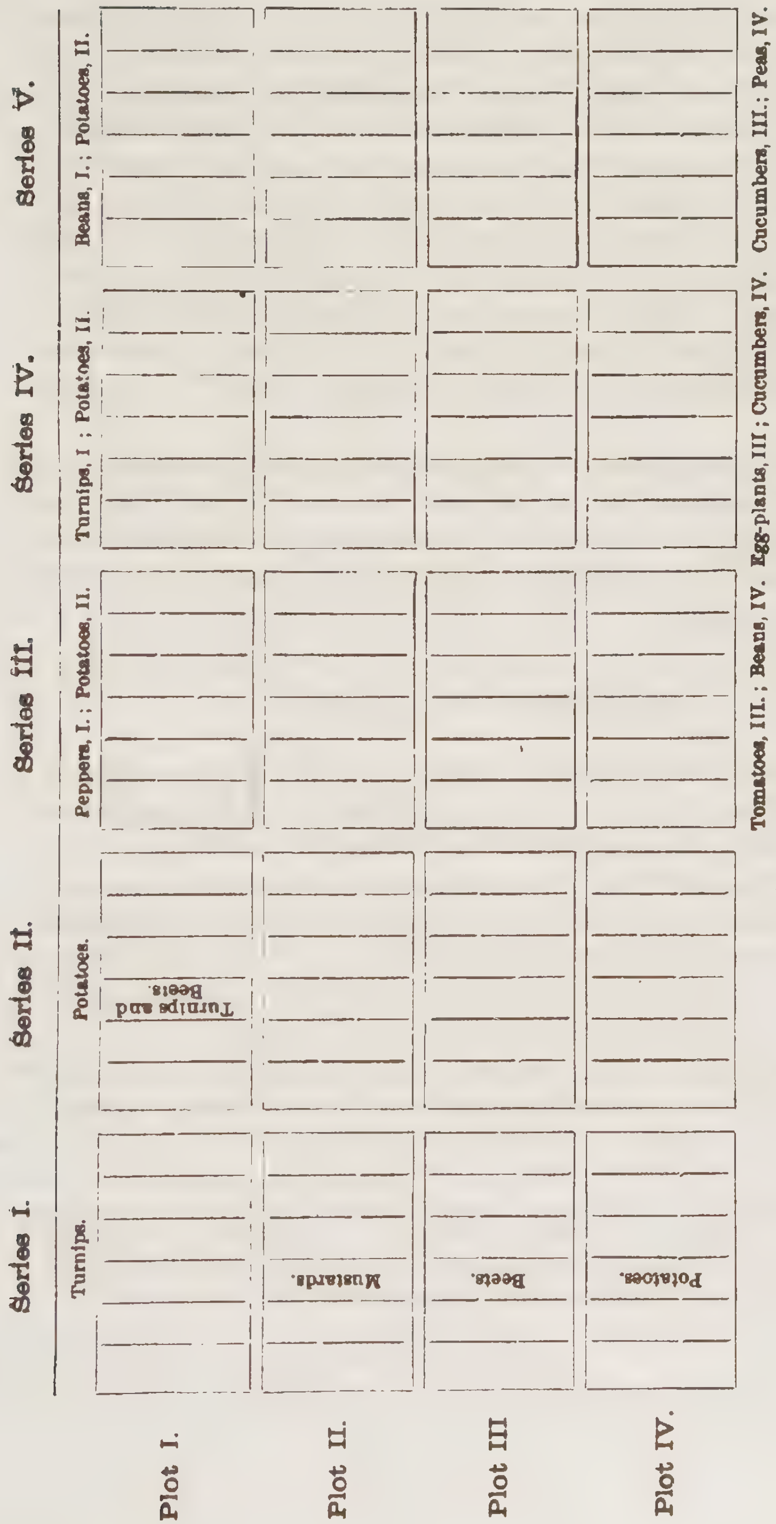

Fig. 3.
The Plan of the Experiment Area for 1896.

occupied Plot II.; egg-plants succeeded egg-plants upon Plot III., and cucumbers were introduced for the first time upon Plot IV. In Series V., Plot I. had beans (Golden Wax) as its fifth successive crop; Plot II., potatoes (American Giants) followed two years in beans; cucumbers for the second year were upon Plot III., and upon Plot IV. peas were introduced for the first time upon the Experiment Area.

To the right of Series V., another series (VI.) was laid out and planted to potatoes (Early Rose), with celery as a second crop upon Plot IV. Still farther to the right is the space devoted to experiments with ornamental plants, and between this and the roadway nine experimental grass plots placed side by side form a border to the trial grounds.

Upon the left of Series I., another has been added (Series 0) that this year was sown to beets for the third season. Beyond this is a narrow strip of land for various purposes, and the area ends in a border of grass plots similar to those upon the opposite side of the experiment grounds.

EXPERIMENTS WITH TURNIPS.

The purpose of the experiments conducted since 1894 in connection with turnips has been to determine a preventive of the destructive disease commonly known as club-root, caused by the fungus *Plasmodiophora Brassicæ* Wor. The malady is also destructive to several other cultivated plants, closely related to and included with it in the same group of plants—the mustard family.

Probably none of the members of this family are more susceptible to the disease in question than the turnip.*

Before considering the experiments of 1896, it may be well to note briefly those of the two preceding seasons, a plan of which is herewith appended.

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*For a description of the disease under consideration, the reader is referred to Bulletin No. 98, "Club-Root of Cabbages and Its Allies." In the report for 1894, pages 278–289, and that for 1895, pages 250–276, will be found an account of the experiments conducted with turnips during the past two seasons.

	Belt 1.	2.	3.	4.	5.	6.
Plot I.	1894. Lime, 300 bushels.	1895, 2d crop sprayed with Bordeaux.	1894. Lime, 150 bushels.	1895, 2d crop Irrigated.	1894. Lime, 75 bushels.	1894. Corrosive sublimate, 5,280 gallons.
Plot II.	1894. Gas-lime, 150 bushels.	1895. Corrosive sublimate, 33¾ pounds.	1894. Gas lime, 75 bushels.	Nothing.	1894. Gas-lime 37½ bushels	1894. Bordeaux. 5,280 gallons. 1895. Corrosive sublimate, 16⅞ pounds.
Plot III	1894. Kainit, 1,920 pounds.	1895. Copper sulphate. 1,200 pounds	1894. Kainit, 960 pounds.	1895, 2d crop Irrigated.	1894. Kainit, 480 pounds.	1894. Cupram, 5,280 gallons. 1895. Copper sulphate, 600 pounds.
Plot IV.	1894. Ashes, 300 bushels.	1894 (Nov.) Lime, 600 bushels.	1894. Ashes, 150 bushels. 1895 (July). Salt, 60) pounds.	1894 (Nov.) Lime, 300 bushels	1894. Ashes, 75 bushels. 1895 (July). Salt, 300 pounds.	1895, 1st crop sprayed with Bordeaux.

Fig. 4.

Plan of Turnip Experiments for 1894 and 1895.

The results obtained after growing four successive crops in soil so treated are summarized from the report of 1895 as follows:

Kainit, applied in the three following amounts, namely, 1,920, 960, and 480 pounds per acre, gave no favorable results as a preventive of club-root, and proved decidedly harmful to the turnips.

Ordinary unleached wood-ashes, when applied in the following amounts, namely, 300, 150, and 75 bushels per arce, respectively, failed to diminish the clubbing of turnips. The ashes act as a fertilizer and increase the size of the roots, but they are not recommended as a remedy for club-root.

Gas-lime, at the rate of 150, 75, and 37½ bushels per acre, respectively, gave no good results with clubbing of turnips. Besides this, gas-lime interfered with the growth of the crop.

Bordeaux mixture, applied in 1894 at the rate of 5,280 gallons per

acre, had no effect upon the club-root fungus, and destroyed more than half the turnips.

Cupram was also applied to a single belt in 1894, and gave no encouraging results.

Sulphate of copper (bluestone), when applied as a powder in early spring at the rate of 1,200 pounds per acre, proved injurious to the crop and did not diminish the club-root, but where the amount was 600 pounds per acre, the stand was good and the clubbing somewhat reduced in the second crop.

Corrosive sublimate was used in both the liquid and powdered form. When applied in powder at the rate of 33¾ pounds per acre, no favorable results were obtained, but with half that amount the crop was an average one in size, and the clubbing much below that of the check belt.

The results that have been obtained with air-slaked lime during the past two years, both in the spring and fall applications, justify its being recommended as a remedy for club-root in turnips and cabbages. The experiments indicate that not more than 150, nor less than 75 bushels per acre, should be used upon badly-infested soil, and the application is more valuable when made in the fall, and the lime left upon the surface during the winter.

TURNIP EXPERIMENTS FOR 1896.

The following diagram (Figure 5) indicates the plan of the experiments for the two turnip crops grown upon Series I. in 1896. The scheme necessarily embraces the soil applications of the present season and those of the two preceding years. Everything is in terms of per acre, and applied in the spring, unless otherwise indicated. The year is followed by whatever is added during that time, and no mention is made of the year when there was nothing applied:

	Belt 1.	2.	3.	4.	5.	6.
Plot I.	1894. Lime, 300 bushels.	1896. Sulphur, 300 pounds.	1894. Lime, 150 bushels.	Nothing. 1895. 2d crop Irrigated.	1894. Lime, 75 bushels. 1896. Irrigated.	1894. Corrosive sublimate, 5,280 gallons. 1895 (Nov.) Blighted tops.
Plot II.	1894. Gas-lime, 150 bushels.	1895. Corrosive sublimate, 33¾ pounds.	1894. Gas-lime, 75 bushels.	Nothing.	1894. Gas-lime, 33½ bushels. 1896. Irrigated.	1894. Bordeaux, 5,280 gallons. 1895. Corrosive sublimate, 16⅞ pounds.
Plot III.	1894. Kainit, 1,920 pounds. 1896. Sulphur. 600 pounds.	1895. Copper Sulphate, 1,200 pounds.	1894. Kainit, 960 pounds.	Nothing. 1895. 2d crop Irrigated.	1894. Kainit. 480 pounds. 1896. 1st crop Irrigated. Carbonate of lime (June), 60 bushels.	1894. Cupram, 5,280 gallons. 1895. Copper sulphate, 600 pounds. Roots (Nov.)
Plot IV.	1894. Ashes, 300 bushels. 1896. Sulphur, 1,200 pounds.	1894 (Nov.) Lime, 600 bushels.	1894. Ashes, 150 bushels. 1895 (July). Salt, 600 pounds.	1894 (Nov.) Lime, 300 bushels.	1894. Ashes, 75 bushels. 1895 (July). Salt, 300 pounds 1896, 1st crop Irrigated Sal soda (June), 60 bushels.	Nothing.

Fig. 5.

Plan of Turnip Experiments for 1896.

As indicated in the above diagram, the plan of the experiments of 1895 varied somewhat from those of the first year, and additional changes have been made the present season. Since 1894, the second belts of each plot, at first used as a check, have each been converted into experiment belts by the addition of different chemicals to their soils, the check of Plot II. receiving an application of corrosive sublimate, that of III., powdered copper sulphate, and IV., lime.

Gas-lime, kainit, and wood-ashes had all proved worthless as preventives of club-root, and the half and quarter-amount applications, at least, had presumably lost most of their characteristic properties by the end of two years. These substances, therefore, were not likely to alter the effect of others that might be added to the same belts, and had probably ceased to have any influence upon the plants grown there.

The belts to which half and quarter-amounts of wood-ashes had been applied in 1894 were treated with common salt in 1895. Two of the cultural belts also received new treatment in 1895, that of Plot II., with Bordeaux in 1894, received half as much corrosive sublimate as was applied at the same time to the first check belt of the same plot. In like manner the cultural belt of Plot III. received a half-strength application of powdered copper sulphate. The tops produced by the second crop in 1895 were spread upon the soil of the cultural belt of Plot I., while the roots were applied to that of Plot III.

In April of the present year, sulphur was applied to the soil of three belts in varying amounts; to the first check belt of Plot I., at the rate of 300 pounds per acre, and the full-strength kainit belt of 1894 received twice as much—600 pounds per acre—while to the full-strength ashes belt of 1894, 1,200 pounds per acre was applied. The half-amount gas-lime belt was reserved for testing the susceptibility to club-root of various members of the mustard family, wild and cultivated. Beet and potato experiments were introduced upon the half-amount kainit and ashes belts of Plots III. and IV.

None of the belts were sprayed, and the foliage of the first crop was infested but little by fungi. The bacterial blight began to be manifest at about the time the crop was harvested, and all the belts seemed to be infested in about the same degree. By June 1st, or about five weeks after the turnips were sown, the presence of the root disease was evident in a majority of the belts. In certain ones all the plants were so severely infested that but little growth had been made above ground after the third week. Others had developed as much foliage as the uninfested plants, but that they were clubbed was recognized by the more or less wilted appearance of their leaves, which were of a much deeper shade of green than is usually assumed by healthy turnip plants.

The cultural belt of Plot I., treated with a dressing of turnip leaves in 1895, and that of Plot III., treated in like manner with turnip roots, were conspicuous for their greatly increased foliage.

Sulphur applied in 1896 nowhere gave evidence of having diminished the degree of clubbing, and none of the substances applied previous to 1896, with the exception of air-slaked lime, appeared to have been of any practical value as club-root preventives.

The first crop was harvested June 18th, and the turnips were badly scabbed, so much so that any attempts to separate and weigh those free from the scab was regarded as a waste of time. Upon the new land (Plot I., Series IV.) the scab was much less than upon the old land.

A large percentage of the roots when cut open showed a discoloration or a watery appearance just below the crown, and some were hollow in the center. All such turnips, when left upon the ground for a few days, turned dark, became slimy, and gave off a very offensive odor. Everything points to bacteria as the cause of this rapid decay. A bushel or so taken to the laboratory for study quickly spoiled, the ordinary soft-rot fungus *Rhizopus nigricans* Ehr. taking an active part in the destruction.

The results of the harvest of the first crop are given in terms of sound and clubbed roots in the accompanying table (Figure 6):

	Belt 1.	2.	3.	4.	5.	6.	
Plot I.	86 pounds. 0	1½ 84	85 1	25 60	76 ½	18 48	Sound. Clubbed.
Plot II.	92 89	5 75	In Crucifers.	1 102	22 97	1 84	Sound. Clubbed.
Plot III.	0 63	0 52½	In Beets.	½ 69	1½ 88	1 84	Sound. Clubbed.
Plot IV.	18 110	95 48	In Potatoes.	72 56	7 60	1 79	Sound. Clubbed.

Fig. 6.

Results in Pounds of First Turnip Crop for 1896.

The percentage of clubbed roots in each belt is herewith given (Figure 7):

	Belt 1.	2.	3.	4.	5.	6.
Plot I.	0	98.41	1.16	70.58	.65	77.41
Plot II.	29.77	98.75	In Crucifers.	99.02	81.51	98.82
Plot III.	100	100	In Beets.	99.45	98.32	98.82
Plot IV.	89.43	84.50	In Potatoes.	48.75	89.55	98.75

Fig. 7.

Results in Percentages of First Turnip Crop for 1896.

A comparison of the first crop of 1896 with that of the average of the four preceding crops shows, for the four check belts, a decided increase in the percentage of clubbing, as indicated in the following table:

	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Average of first four crops...	21.4	87.43	87.36	82.94
First crop, 1896..................	70.58	99.02	99.45	98.75

In the limed belts there is seen to be a marked falling off in the percentage of clubbing from that of the average of the four preceding crops, as the following table shows:

	Per Cent.	Per Cent.	Per Cent.
Average of first four crops.......................	3.48	10.32	3.20
First crop, 1896....................................	0	1.16	.65

The first crops produced upon the limed belts in 1895 and 1896 were both practically free from clubbing. There were 2.77 per cent. of clubbed roots in the first crop of 1895 in the full-amount belt and none in 1896, although the yield was more than double that of the corresponding crop of the preceding year.

There was an increase of clubbing in the half-amount belt, and a decrease in the quarter-amount belt, but the difference was less than one per cent. in either case. The percentage of clubbed roots in the second crop produced in the limed belts in 1895 was greater than the first in 1896 by 14.84 per cent. in the half-amount belt, and 6.36 per

cent. in the quarter-amount belt. In neither the second crop of 1895 nor the first of 1896 was there clubbing in the full-amount belt.

In the two check belts of Plot IV., treated in November, 1894, with lime at the rate of 600 and 300 bushels per acre, respectively, the percentage of clubbed roots was much lower than in the surrounding belts. The clubbing was somewhat less than in the first crop of 1895, but considerably greater than in the second of 1895. Compared with the average of the two preceding crops, the percentage of clubbed roots in the first crop of 1896 upon the full-amount belt will be seen to be almost the same, but in the half-amount belt it is considerably increased.

	Per Cent.	Per Cent.
Average of the two preceding crops	33.68	30.49
First crop in 1896	34.50	43.75

A comparison of the percentage of clubbing in the gas-lime belts for the first four crops and for the first crop of 1896 is given below:

	Per Cent.	Per Cent.	Per Cent.
Average of first four crops	49.74	80.57	60.87
First crop in 1896	29.77	....	81.51

There is seen to have been a noticeable decrease in the percentage of clubbing in the full-amount belt and a corresponding increase in the quarter-amount belt. In the half-amount belt, as previously stated, no turnips were grown the present season.

In Plot III., the first kainit belt had been treated with sulphur, while the second was devoted to beets, so that only the quarter-amount belt remained in condition to have its first crop for 1896 compared with those preceding it upon the same area.

The percentage of clubbing in the quarter-amount belt was considerably higher than that of the average of the four preceding crops, as the following table shows:

	Per Cent.
Average of first four crops	83.39
First crop in 1896	98.32

The first ashes belt of Plot IV. was treated with sulphur, and potatoes were grown upon the second. The quarter-amount belt, to which salt at the rate of 300 pounds per acre had been applied in 1895, showed an increase in the percentage of clubbed roots, as indicated below:

	Per Cent.
Average of first four crops	68.81
First crop in 1896	89.55

Corrosive sublimate was applied in the spring of 1895 to belts 2 and 6 of Plot II. at the rates of $33\frac{3}{4}$ pounds and $16\frac{7}{8}$ pounds per acre respectively, and gave no indication the present season of having had any effect upon the root disease, as the following table shows:

	Per Cent.	Per Cent.
Average clubbing of first two crops	76.37	37.67
First crop in 1896	93.75	98.82

In belt 6 of Plot I., there had been, previous to 1896, very little clubbing—11.76 per cent. being the highest. Corrosive sublimate in liquid form of standard strength (1 to 1,000) had been added to this belt in 1894, and it would seem, therefore, to have been of value as a club-root fungicide. In the first crop of the present season, however, the percentage of clubbing had increased to 77.41 per cent., indicating that if corrosive sublimate prevented clubbing heretofore, a second application was necessary, since the first had evidently parted with its fungicidal properties. It is not unlikely that the belt in question was freer from the germs of the root disease at the beginning than were surrounding belts, and that the solution applied was therefore credited with greater value than it possessed. As already stated, corrosive sublimate applied in solid form proved worthless as a preventive of club-root.

Like results were obtained the present season in belts 2 and 6 of Plot III., treated in the spring of 1895 with copper sulphate at the rates of 1,200 and 600 pounds per acre, respectively:

	Per Cent.	Per Cent.
Average of first two crops	89.84	70.22
First crop in 1896	100.00	98.82

Sulphur was applied in April, 1896, to belt 2 of Plot I., and seemed to have no effect upon the root disease. The percentage of increase in clubbed roots in the belt so treated was even greater than in the check belt of the same plot. Like negative results were obtained in the first belts of Plots III. and IV., treated with sulphur at the rate of 600 and 1,200 pounds per acre, respectively.

A second crop of turnips was sown July 1st of the same variety as that of the first, namely, the Early Snowball. No changes were introduced except in Plots III. and IV. To belt 5 of the former calcium carbonate was added at the rate of 3,000 pounds per acre, while sodium carbonate (sal soda) was applied at the same rate to belt 5 of Plot IV.

At the end of two months (August 31st) the crop, a very small one, was harvested, and the results obtained are presented in the following tables (Figures 8 and 9):

	Belt 1.	2	3.	4.	5.	6.	
Plot I.	4¾ pounds. 0	0 7½	1½ ⅛	0 5½	¾ 0	4½ 8¼	Sound. Clubbed.
Plot II.	½ ¼	0 6½	In Crucifers.	0 18¾	¼ ¾	½ 3½	Sound. Clubbed.
Plot III.	0 8½	0 7¼	In Beets.	0 8¼	0 3½	0 12½	Sound. Clubbed.
Plot IV.	0 12¼	4 ½	In Potatoes	5½ ¼	0 7¼	0 4	Sound. Clubbed.

Fig. 8.

Results in Pounds of Second Turnip Crop for 1896.

As might be expected of turnips grown at so unfavorable a season, the yield was extremely light, and there were no roots of a marketable size, even among the unclubbed. But the extreme heat of midsummer, although detrimental to the normal development of turnips, seemed to have an opposite effect upon the parasite preying upon their roots. When harvested, the turnips were found to be distorted to a much greater degree than any grown upon the same land since the experiment began.

	Belt 1.	2.	3.	4.	5.	6.
Plot I.	0	100	7.61	100	0	64.70
Plot II.	33.33	100	In Crucifers.	100	75	87.50
Plot III.	100	100	In Beets.	100	100	100
Plot IV.	100	11.11	In Potatoes.	4.08	100	100

Fig. 9.

Results in Percentages of Second Turnip Crop for 1896.

In the five limed belts the yield was rather below the average for the series, but the percentage of clubbed roots was very light. The full and quarter-amount belts of Plot I. contained no clubbed roots, while in the half-amount belt 7.61 per cent. were slightly clubbed. Compared with the average of the five preceding crops the results are seen to be favorable to the last crop:

	Per Cent.	Per Cent.	Per Cent.
Average of first five crops	2.09	8.50	2.68
Second crop in 1896	0	7.61	0

The full-amount lime belts (600 bushels per acre) in Plot IV. contained 11.11 per cent. of clubbed roots, and the half-amount belt only 4.03 per cent. Compared with the first crop of 1896, there was seen to have been a decrease in the percentage of clubbed roots of 23.39 per cent. in the full-amount belt, and 39.72 per cent. in the half-amount belt. There was also a decided falling off in the percentage of clubbed roots as compared with the average of the three preceding crops upon the two belts here considered, as shown below:

	Per Cent.	Per Cent
Average of first three crops	33.95	34.91
Second crop in 1896	11.11	4.03

In all the remaining belts of Plot IV. and in all the belts of Plot III. the percentage of clubbed roots was 100.

The two belts to which calcium carbonate and sodium carbonate had been applied yielded none but clubbed roots. The sodium carbonate proved somewhat injurious to the turnips, there being only about half a stand in the belt so treated. Of the other substances that had been added to the various belts, it need only be said that all failed, as they had previously done, to act as club-root fungicides.

SUMMARY.

Kainit applied in 1894 at the rate of 500 pounds per acre has given no results during the past three seasons as a club-root fungicide. Twice and four times the above amount of kainit has been found equally ineffective and besides proved harmful to the turnip plants.

Gas-lime either at the rate of 150 or 75 bushels per acre has been of no practical value as a club-root preventive. It does, however, seem to have some effect upon the development of the malady, since the increase in clubbing in the belts so treated has been less than in the checks.

Copper sulphate (bluestone) applied in powdered form in 1895 at the rate of 1,200 and 600 pounds per acre respectively, proved injurious to the turnip crop, and had no effect upon the club-root fungus.

Corrosive sublimate, when applied in solution, at the rate of 5,380 gallons per acre, seems to have been of value as a club-root fungicide previous to the present season. The last two crops upon the belt so treated have been badly clubbed. The same chemical applied in powdered form at the rate of 33.75 and 16.8 pounds per acre in 1895, has proved of no use as a fungicide, and in case of the larger amount was highly injurious to the plants.

Salt (sodium chloride) of the ordinary sort applied to two belts at the rate of 600 and 300 pounds per acre respectively, did not have any appreciable effect upon either the club-root or the turnips.

Sulphur applied the present season at the rate of 1,200, 600 and 300 pounds per acre respectively, had no apparent effect as a preventive of club-root. On the contrary, the percentage of clubbing was found to have increased in the three belts so treated, at essentially the same rate as in their respective check belts.

Calcium carbonate applied at the rate of 3,000 pounds per acre, just previous to the sowing of the second crop of 1896, did not reduce the percentage of clubbing.

Sodium carbonate applied at the same time and in the same amount as the calcium carbonate was equally ineffective as a club-root fungicide and proved harmful to the plants. A further trial of the two last-mentioned chemicals should be made before deciding upon their fungicidal merits.

Lime, freshly slaked, was applied to three belts of Plots I. in the spring of 1894 at the rate of 300, 150, and 75 bushels per acre, respectively. The largest application has continued to keep down the percentage of clubbing to almost nothing for the past three years, but the stand of turnips has, until the present season, been considerably reduced. The half and quarter-amount applications have proved, almost as effective, as fungicides, and have not interfered with the growth of the plants, when the crop has been grown in its proper season.

In November, 1894, lime was applied to two belts in another and more thoroughly-infested portion of the series, at the rate of 600 and 300 bushels per acre, respectively. It was left upon the surface until spring, and then worked into the soil. The excessive amounts applied

did not injure the crops produced there, and the number of clubbed turnips was greatly diminished. The percentage of clubbing in the first crop of 1896 was considerably increased, which would seem to indicate that a second application was necessary.

Air-slaked stone-lime, therefore, has thus far proved to be the only substance of any practical value as a club-root preventive. Its use is recommended in amounts not greater than 150 nor less than 75 bushels per acre. The experiments thus far seem to indicate that the applications to severely-clubbed land in which turnips, cabbages or allied plants are yearly grown, should be made every other year. It is advisable to spread the lime upon the surface of the land in the fall and not turn it under until the following spring.

Further Experiments with Turnips.

In order to test the longevity of the club-root fungus in the soil, Plot I., Series IV., was sown to turnips upon April 21st and harvested upon the 22d of June. This plot had been in potatoes in 1894 and beans and celery in 1895, turnips having been grown there in 1892–93.

Belt 1.	2.	3.	4.	5.	6.	
126	125.5	111	99.5	122.5	120	Roots.
69	87	29	26	28	38	Sound.
58	33	78	67	88	77	Clubbed.
4.5	5.5	4	6.5	6.5	5	Bacterial Rot.
196	155	146	157	160	190	Tops.
322.5	280.5	257	256	282.5	310	Total.

Fig. 10.

Results in Pounds of the First Turnip Crop of Plot I., Series IV., in 1896.

The accompanying table (Figure 10) shows the yield of roots. It is seen at a glance that there is a large amount of clubbing. Of the total of 705 pounds of roots, 446 are clubbed and 32 pounds had a soft malodorous decay that is charged to some micro-organism and is termed "bacterial rot" in the table. Belt 5 received a liberal application of water, and the results show the largest percentage of clubbing and of bacterial decay of any of the belts.

This land test indicates that two years are entirely inadequate for the removal of the club-root fungus from the soil. In this case the ground was subjected to clean culture, and there was no opportunity for weeds that breed the disease to have aided in preserving the germs in the soil. While it is impossible to deduce from the single experi-

ment a principle to guide in the matter of crop rotation, the indications are that quite a number of years needs to elapse before land well charged with club-root germs will be suitable again for turnips or cabbages, unless direct soil treatment is practiced.

It was hoped that this soil, after the two years in other crops, might be comparatively free from the club-root, and for the second crop a series of soil inoculations with the club-root germs had been planned. They were, however, carried out, it being borne in mind that while there was a large percentage of the club-root it was very evenly distributed over the whole plot.

For this experiment, five bushels of thoroughly-clubbed turnips were selected at harvest time from the turnip series. All of the turnips were sliced through a root cutter, and one bushel was soaked two hours in corrosive sublimate solution of twice the standard strength (1 to 500), and then applied to belt 1 and spaded into the soil. To the next belt the bushel of clubbed roots was applied after having first been boiled for three hours. Upon belt 3 a bushel untreated was added, along with a quantity of manure. The next belt (4) was left without any application of roots and served as the check upon the other five belts. A bushel of the clubbed roots was fed to a heifer and the manure applied to belt 5, and upon belt 6 the turnips were applied without either previous treatment or manure.

The accompanying table (Figure 11) gives the results of this experiment. The extremely hot weather was unfavorable for the second crop of the early sort of turnip (Snowball) and the yield is small.

Belt 1.	2.	3.	4.	5.	6.	
13.5	24	11	28.5	9	9.25	Roots.
0	0	0	.5	0	0	Sound.
13.5	24	11	28	9	9	Clubbed.
2.5	7	2.5	7.5	2.25	2.25	Tops.
16	31	13.5	36	11.25	11.5	Total.

Fig. 11.

Results in Pounds of the Second Turnip Crop of Plot I., Series IV., in 1895.

It is seen that the largest yield in both tops and roots is upon the check belt, where no clubbed roots in any form were applied. This was the only belt yielding any sound roots. The next belt is where the turnips were boiled for three hours, the thought in this feature being to test the action of heat upon the germs, and it seems likely that they were thereby destroyed. The poorest crop was where the

manure from the animal fed upon clubbed roots had been applied, but there is only a little difference between this one and belt 6, where the same amount of roots was placed directly upon the land.

Box Experiment with Turnips.

With the exception of belt 1, with the corrosive sublimate, the above-detailed experiment was carried out in boxes in the greenhouse. The soil employed was that used generally in the greenhouse and not from the experiment area, and contained manure from mule stables located in the city. There is no likelihood that the soil contained any germs of club-root. Stated in the order of the belts in the corresponding plot in the field, omitting No. 1 for the corrosive sublimate, the boxes are: No. 2, to which the boiled turnips were applied; No. 3, bearing clubbed roots and fresh manure from cow stables; No. 4, the check; No. 5, manure from heifer fed with clubbed roots, and No. 6, simply clubbed roots added to the soil. These boxes were two feet square and the turnips came up by the hundred, and were afterwards thinned to about fifty. At the end of five weeks (June 25th to August 2d) the roots were pulled with the following results. Neither the check nor the box with the boiled pulp added showed any clubbing, while in the three having received the diseased roots all were badly clubbed and no difference in degree could be distinguished. Figure 12 is made from a photograph of a sample root from each of four boxes. Root No. 1 is from the check box, No. 2 from where manure and clubbed roots were added to the soil, No. 3 from where clubbed roots were added, and No. 4 from where the manure of a heifer fed upon clubbed roots was applied.

From this box experiment it may be inferred that with land perfectly clean of the germs, manure may become a vehicle for the transfer of the disease, and this suggests a caution in the use of diseased turnips for feeding farm animals.

Testing of Other Plants for Club-root.

In order to test the comparative susceptibility to club-root of other members of the mustard family, one belt in the turnip series was devoted to a long list of cruciferous plants. The land selected was the half-amount gas-lime belt, where the turnips for the four previous crops had been very badly clubbed and the soil must have contained a large amount of the fungus causing the disease.

Fig. 12.
Samples of Turnip Roots from the Box Experiments.

The following is the list of species that were tested. The rows ran the short way of the belt and after a row of each kind of seeds had been sown the series was duplicated upon the remaining half of the belt:

No.	Common Name.	Botanical Name.	Rank of the Clubbing.
1	Candytuft	(*Iberis umbellata* L.)	11
2	Sweet alyssum	(*Alyssum maritimum* Lam.)	12
3	Wild sweet alyssum	(*Alyssum alyssoides* L.)	13
4	Shepherds' purse	(*Bursa Bursa-Pastoris* L.)	7
5	Rockcress	(*Arabis lævigata* (Muhl.) Poir.)	4
6	Wormseed mustard	(*Erysimum cheiranthoides* L.)	5
7	Peppergrass	(*Lepidium Virginicum* L.)	8
8	Field peppergrass	(*Lepidium campestre* Br.)	6
9	Stock	(*Matthiola annua* Sw.)	
10	Pennycress	(*Thalaspi arvense* L.)	3
11	Cultivated radish	(*Raphinus sativus* L.)	14
12	Rocket	(*Hesperis matronalis* L.)	15
13	Black mustard	(*Brassica nigra* L.)	9
14	Charlock	(*Brassica Sinapistrum* Bois.)	1
15	White mustard	(*Sinapis alba* L.)	2
16	False flax	(*Camelina sativa* (L.) Cranz)	10

All but one (stocks) of the 16 species furnished roots that were more or less affected with the club-root. Charlock, so far as this experiment is concerned, was the most thoroughly infested, followed closely by the white mustard. There was remarkably less disease in the black mustard than in the two above named, for its rank was nine, as shown by the figure appended to each species. Pennycress was third in the list, rockcress fourth, wormseed mustard fifth, field peppergrass sixth, and so on. Among the kinds that were least affected were rocket, radish, the alyssums and candytuft.

EXPERIMENTS WITH POTATOES.

For the last three years, the series (II.) of the experiment area has been devoted to potatoes, the leading effort being to obtain a satisfactory remedy for the potato scab *Oospora scabies* Thax.*

That the reader may be prepared for the experiments and results of the present year, the plan of the series for the previous season is here introduced with some remarks upon the results therein shown.

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* The reader will find in Bulletin No. 112 a general description of this pest, with an engraving of a badly-scabbed potato. Please also consult the reports for 1894, pages 291–295, and 1895, pages 267–275, giving full details of the potato experiments for the last two years.

	Belt 1.	2.	3.	4.	5.	6.
Plot I.	1894. Lime. 300 bushels. 1895. Scabby, 100 per ct. 134 pounds.	1895. Seed soaked 1 hour in corrosive sublimate (1–500). Scabby. 100 per ct. 115 pounds.	1894. Lime, 150 bushels. 1895. Scabby, 100 per ct. 150 pounds.	1895. Nothing. Scabby, 97 per ct. 126 pounds.	1894. Lime, 75 bushels. 1895. Scabby, 98 per ct. 133 pounds.	1894. Corrosive sublimate, 4,320 gallons. 1895. Scabby, 80 per ct. 108 pounds.
Plot II.	1894. Gas-lime. 150 bushels. 1895. Scabby, 100 per ct. 105 pounds.	1895. Seed soaked 1 hour in corrosive sublimate (1–1,000). Scabby. 100 per ct. 70 pounds.	1894. Gas-lime. 75 bushels. 1895. Scabby. 100 per ct. 108 pounds.	1895. Nothing. Scabby, 100 per ct. 108 pounds.	1894. Gas-lime, 37½ bushels. Scabby, 100 per ct. 90 pounds.	1894. Bordeaux, 4,320 gallons. 1895. Scabby, 70 per ct. 107 pounds.
Plot III.	1894. Kainit, 1,920 pounds. 1895. Scabby, 100 per ct 133 pounds.	1895. Seed soaked 1 hour in corrosive sublimate (1–2,000). Scabby, 100 per ct. 186 pounds.	1894. Kainit. 960 pounds. 1895. Scabby. 100 per ct. 126 pounds.	1895. Nothing. Scabby, 100 per ct. 144 pounds.	1894. Kainit. 480 pounds. 1895. Scabby. 100 per ct. 126 pounds.	1894. Cupram, 4,320 gallons. 1895. Scabby, 80 per ct. 104 pounds.
Plot IV.	1894. Ashes, 300 bushels. 1895. Scabby, 100 per ct. 181 pounds.	1895. Seed soaked 1 hour in corrosive sublimate (1–4,000). Scabby, 100 per ct. 133 pounds.	1894. Ashes, 150 bushels. 1895. Scabby, 100 per ct. 128 pounds.	1895. Nothing. Scabby, 100 per ct. 116 pounds.	1894. Ashes, 75 bushels. 1895. Scabby, 100 per ct. 120 pounds.	1895. Sulphur, 300 pounds. Scabby, 5 per ct. 101 pounds.

Fig. 13.

Plan and results of Potato Experiments at College Farm for 1895.

During the year 1895 an acre of land in a section of the State (Freehold) where the scab had caused a failure of the crop the previous year, was experimented upon and the results from this field and those of the home series are here condensed. In the Freehold experiment six substances were tested, namely, lime, sulphur, manure, corrosive sublimate, kainit and copper sulphate, each being used in three amounts upon as many separate plots.

In the series at the College Farm the diagram shows that scab abounded, all the potatoes being marked upon nearly every belt. As the land had been in cabbages the year before and treated for club-root with lime, gas-lime, kainit and wood-ashes, these substances are recorded for their respective belts in the diagram given for the potato crop that followed directly upon the cabbage. It will be seen that lime in all three of its amounts proved no remedy for the scab. The same results were obtained for lime from the Freehold experiments,

and they accord with those from other Experiment Stations in various parts of the United States. Manure, it was shown, tends to increase the amount of the scab, it being 60 per cent. as against 47 where no manure was used.

In the Freehold experiments the kainit showed strong fungicidal effects. The plots with the three chemicals that alternated with the three fertilizers all had less scab than the plots receiving nothing, sulphur leading, with corrosive sublimate and copper sulphate third.

The experiments upon the home series confirm the results obtained at Freehold in a most emphatic manner, so far as sulphur is concerned, for in the belt upon which it was used at the rate of 300 pounds per acre, the potatoes were nearly free from scab, while the control belts averaged nearly 100 per cent. On the other hand, the corrosive sublimate used in the ordinary way, tested in four different strengths, failed to show any less scab than the untreated seed.

The report of the results of experiments with the potato scab closed last year with the following words: "For the Irish potatoes, it is suggested that the flowers of sulphur, costing two or three cents a pound, be used with the freshly-cut seed in the hopper of the planting machine."

Before taking up the experiments for the present year, it may be said in passing that the results for 1895 were so encouraging that large numbers of potato-growers throughout New Jersey and in other States acted upon them and used sulphur as a preventive of the scab. Many such growers have reported excellent results, some of them being highly gratified with their returns. No one has expressed any word that has not been in confirmation of the original experiments. In short, the growers were so willing to test the sulphur for themselves that there seemed no need for the Experiment Station to conduct further trials throughout the State.

Experiments in 1896.

Some changes were made upon the potato series of the experiment area from those of the previous year, chiefly in the increase in the number of belts receiving sulphur, the addition of more kainit belts, the introduction of the "Early Rose" and "American Giant" sorts as a variety test for the scab and four belts were irrigated.

The accompanying plan gives the treatments each belt has received for the past two seasons.

	Belt 1.	2.	3.	4.	5.	6.
Plot I.	1894. Lime. 300 bushels. 1895. Scabby. 100 per ct. 134 pounds 1896. *Scabby 75 per ct. 38 pounds.	1895. Seed soaked 1 hour in corrosive sublimate (1–500). Scabby, 100 per ct. 115 pounds. 1896. Sulphur, 120 pounds. Scabby, 50 per ct. 76 pounds.	In Turnips and Beets.	1895. Nothing. Scabby, 97 per ct. 126 pounds. 1896 (Early Rose). Scabby, 85 per ct. 55 pounds.	1894. Lime, 75 bushels. 1895. Scabby, 98 per ct 133 pounds. 1896. Irrigated. Scabby, 75 per ct. 76 pounds.	1894. Corrosive sublimate, 4,320 gallons. 1895. Scabby, 80 per ct. 108 pounds. 1896. Corrosive sublimate, 4,320 gallons. Scabby, 10 per ct. 81 pounds.
Plot II.	1894. Gas-lime, 150 bushels. 1895. Scabby, 100 per ct. 105 pounds. 1896. Scabby, 75 per ct 109 pounds.	1895. Seed soaked 1 hour in corrosive sublimate (1–1,000). Scabby, 100 per ct. 70 pounds. 1896. Sulphur, 240 pounds. Scabby, 50 per ct. 109 pounds.	1894. Gas-lime. 75 bushels. 1895. Scabby. 100 per ct. 108 pounds. 1896. Kainit, 600 pounds. Scabby, 45 per ct. 83 pounds.	1895. Nothing. Scabby, 100 per ct. 108 pounds. 1896. Scabby, 70 per ct. 75 pounds.	1894. Gas-lime, 87½ bushels. Scabby, 100 per ct. 90 pounds. 1896. (Am. Giants). Irrigated. Scabby, 50 per ct. 25 pounds.	1894. Bordeaux, 4,320 gallons. 1895. Scabby, 70 per ct. 107 pounds. 1896. Bordeaux, 4,320 gallons. Scabby, 50 per ct. 64 pounds.
Plot III.	1894. Kainit, 1,920 pounds. 1895. Scabby, 100 per ct 183 pounds. 1896. Scabby, 85 per ct. 92 pounds.	1895. Seed soaked 1 hour in corrosive sublimate (1–2,000). Scabby, 100 per ct. 186 pounds. 1896. Sulphur, 600 pounds. Scabby, 65 per ct. 88 pounds.	1894. Kainit. 960 pounds. 1895. Scabby, 100 per ct. 126 pounds. 1896. Kainit, 1,200 pounds. Scabby, 70 per ct. 19 pounds.	1895. Nothing. Scabby, 100 per ct. 144 pounds. 1896 (Am. Giants). Scabby, 75 per ct. 34 pounds	1894. Kainit, 480 pounds. 1895. Scabby, 100 per ct. 128 pounds 1896. Irrigated. Scabby, 85 per ct. 107 pounds.	1894. Cupram, 4,320 gallons. 1895. Scabby, 80 per ct. 104 pounds. 1896. Cupram, 4,320 gallons. Scabby, 75 per ct. 87 pounds.
Plot IV.	1894. Ashes, 300 bushels. 1895. Scabby, 100 per ct. 181 pounds. 1896. Seed soaked 2 hours in corrosive sublimate (1–500). Scabby, 90 per ct. 69 pounds.	1895. Seed soaked 1 hour in corrosive sublimate (1–1,000). Scabby, 100 per ct. 133 pounds. 1896. Seed rolled in sulphur. Scabby, 90 per cent. 99 pounds.	1894. Ashes, 150 bushels. 1895. Scabby, 100 per ct. 126 pounds. 1896. Seed soaked 2 hours in kainit (1–100). Scabby, 80 per cent. 67 pounds.	1895. Nothing. Scabby, 100 per ct. 116 pounds. 1896. Scabby, 90 per ct. 90 pounds.	1894. Ashes, 75 bushels. 1895. Scabby, 100 per ct. 120 pounds. 1896. (Early Rose). Irrigated. Scabby, 100 per ct. 81 pounds.	1895. Sulphur, 300 pounds. Scabby, 5 per ct. 101 pounds. 1896. Scabby, 5 per ct. 82 pounds.

Fig. 14.

Plan and results of Potato Experiments at College Farm for 1896.

*In 1895 the percentage of scabbiness was determined by the presence of the scab upon each potato, and in 1896 the amount of scab taken as a whole. That is, in 1895 one hundred per centum meant that every tuber was more or less scabby, but the present year it was thought best to change the basis of the percentages to the amount of scabbiness, the worst belt, where all the potatoes were almost literally covered with scabs, being taken as representing the 100 per cent., and all other belts were compared with that one.

It will be seen at a glance that scab was common to the field and most abundant in the lower plots, a fact that has obtained for the three years the series has been in potatoes. The largest amount of scab was with the Early Rose variety, the belt in this sort in Plot IV. being taken as the maximum of 100 per cent. with which to compare the other belts. The Giants were planted in two belts, that this variety, sometimes mentioned as exempt from the scab, might be fully tested as to its susceptibility. While it is a fact that the scab does not work as deeply in this variety as in the Early Rose, it is true that when placed in a scabby soil the Giants will scab badly, as the percentages for its belts will show in the diagram. Of the three varieties represented in the series, the Early Rose is the most susceptible and the Giants the least, with the Rural No. 2 taking a position midway between them. It is not, of course, demonstrated in this experiment, but the indications are strongly in favor of the opinion that no variety of the Irish potato is absolutely exempt from attacks of the scab fungus. The degree of susceptibility may reside in the characteristics of the outer layer of the tuber.

Turning to Plot I., it is seen that in the belt (1) with lime of three years' residence in the soil, the yield was very small and poor. The adjoining belt with sulphur, 120 pounds per acre, added, gave a fair yield and the scabbiness much reduced. The belt in this plot, with corrosive sublimate added to the soil, gave the smallest yield of all the belts in the field, but the potatoes were but little marked with the scab. In Plot II., the best belt by large odds is the one receiving the sulphur, 240 pounds per acre, followed by the one with kainit. The largest yield in Plot III. is upon the irrigated belt, where the scab is very severe. Here again the best results, considering both yield and scabbiness, are in the belt receiving the sulphur. Plot IV. represents the end of the area of potato ground that has the largest percentage of scab. Here the seed treatment was made with corrosive sublimate, sulphur and kainit, leaving one check, one for irrigation and one where sulphur was added to the soil for the previous crop. It will be seen that the worst potatoes were in the irrigated belt, which were literally covered with deep patches of scab. There was no noticeable difference between the belts treated with corrosive sublimate (1 to 500 for two hours), sulphur and the check, although the largest yield was upon the one with the sulphur. The kainit belt gave a lower yield and somewhat smaller percentage of scab. The most striking fact in this plot is the good-sized crop of potatoes, and

almost entirely free from scab, produced upon the belt that received sulphur, three hundred (300) pounds per acre, in 1895. This seems to be entirely the result of the lasting fungicidal effects of sulphur. It will be seen by a glance at the diagram that the adjoining belt had 100 per cent., while this gave only 5 per cent. of scab.

Bordeaux and cupram were again added to their respective belts, and show good results in checking the scab. Aside from these standard fungicides for spraying, the results indicate that for soil treatment for the scab, sulphur takes the lead, that its good effect is lasting when added to the soil; but when the soil is badly infested, there is no hope of checking it successfully by simply rolling the seed in the sulphur. This is a good thing to do in addition to the sprinkling in the open row, for experiments show that instead of injuring the freshly-cut "seed" it keeps it from drying out, and might well replace land plaster for this purpose when "seed" is cut some time before planting.

The experiments indicate that corrosive sublimate will check the scab when the soil is badly infested, but the mere soaking of the seed is ineffective and it needs to be added to the soil. The proper amount is not determined, for the quantity employed proved injurious to the crop and a very light yield resulted, mostly from a replanting of missing hills. The same failure of the plants to come up well was experienced with the kainit belts, and here while the scab was checked the yield was light.

It is not unlikely that a proper amount of kainit mixed with sulphur, about 300 pounds of the former to an equal weight of the latter, would give a combination of fungicide and fertilizer that may prove of great value on the scab-infested farms of the potato-growing regions of our State.

Two engravings from photographs have been made from the crops of five belts the present year that correspond with those published in the last report. Figure 15 shows the largest 25 tubers from the corrosive sublimate, Bordeaux, cupram, nothing and sulphur belts.

The interested reader may find it instructive to compare this with the engraving (Figure 21) in last year's report of similar piles from the same belts. The relative amounts of scab upon the potatoes hold nearly the same during the two years.

The duplicate of Figure 22 of last year's report is shown in Figure 16, it being remembered that the good effect of the sulphur shown in the engraving is after the fungicide has been in the soil since the spring of 1895.

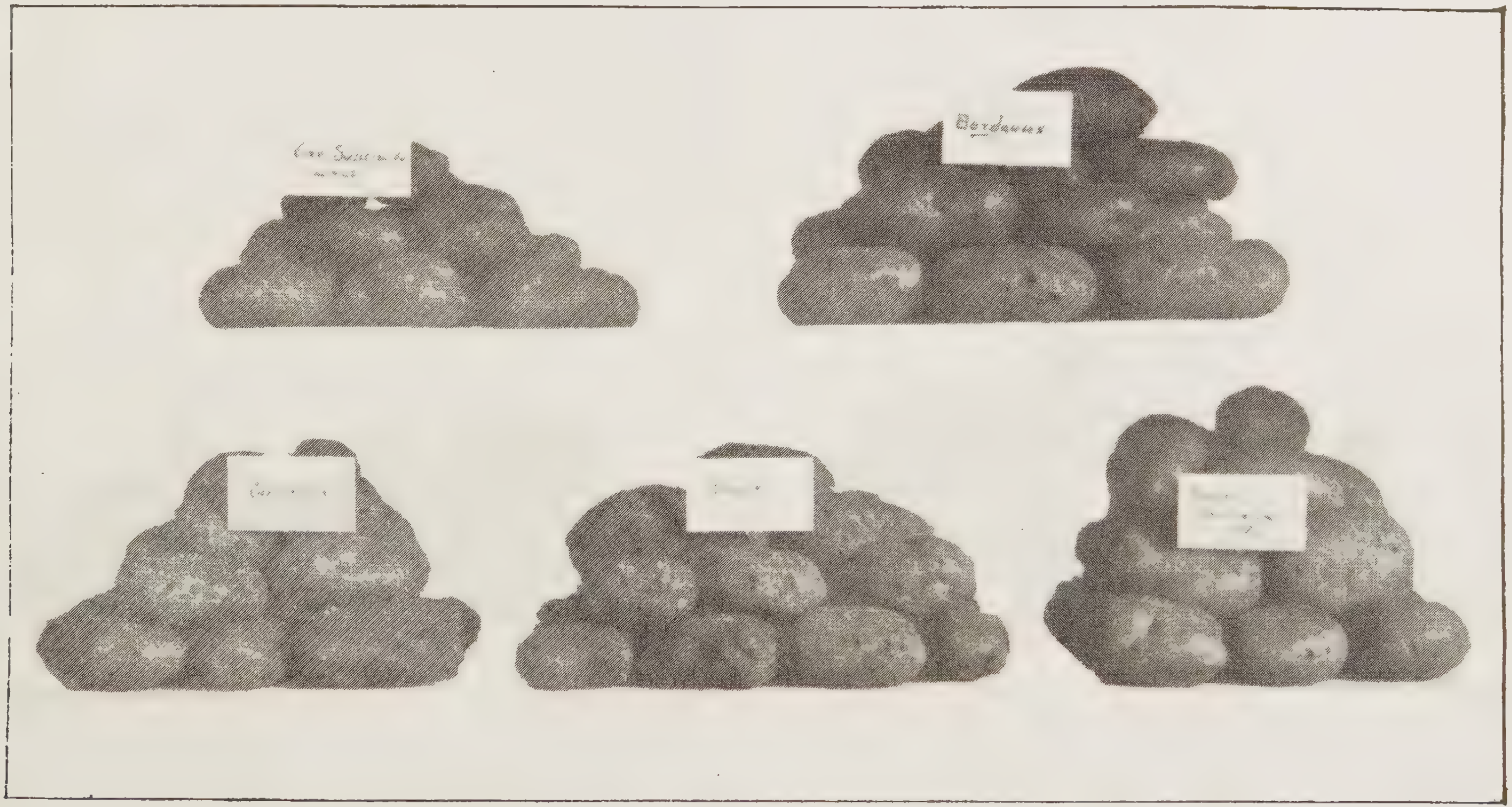

Fig. 15.

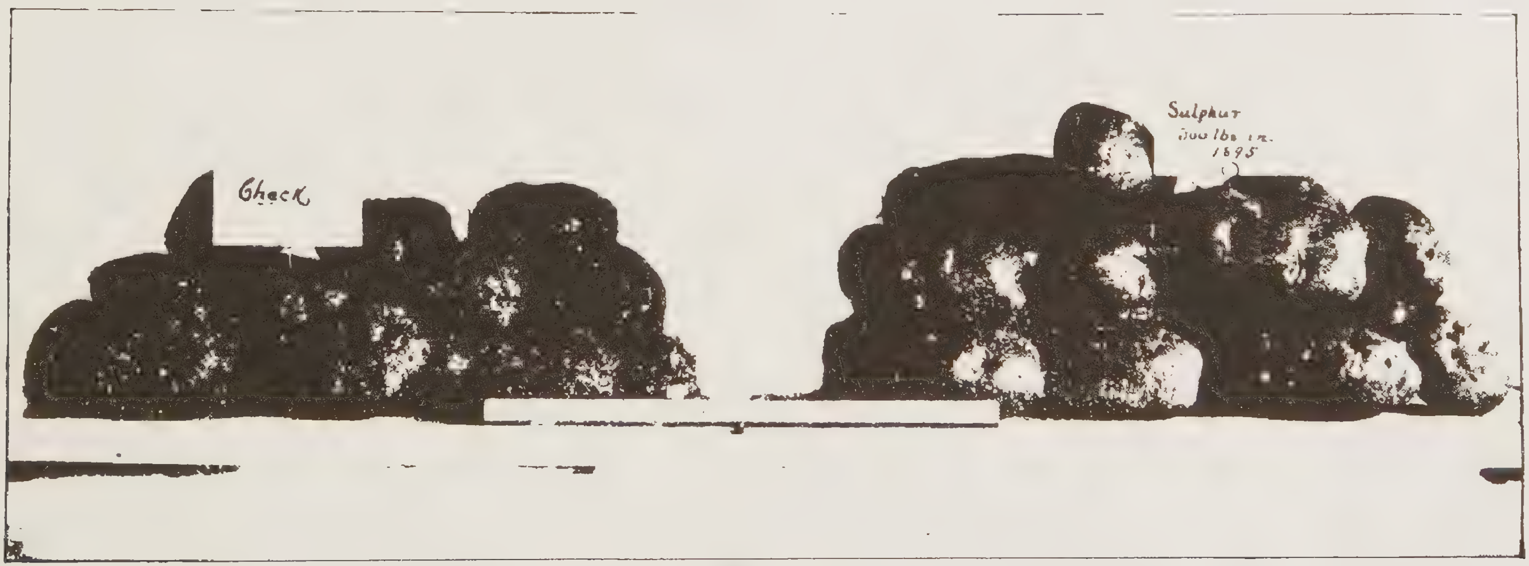

Fig. 16.
A larger view of the Check and Sulphur Piles.

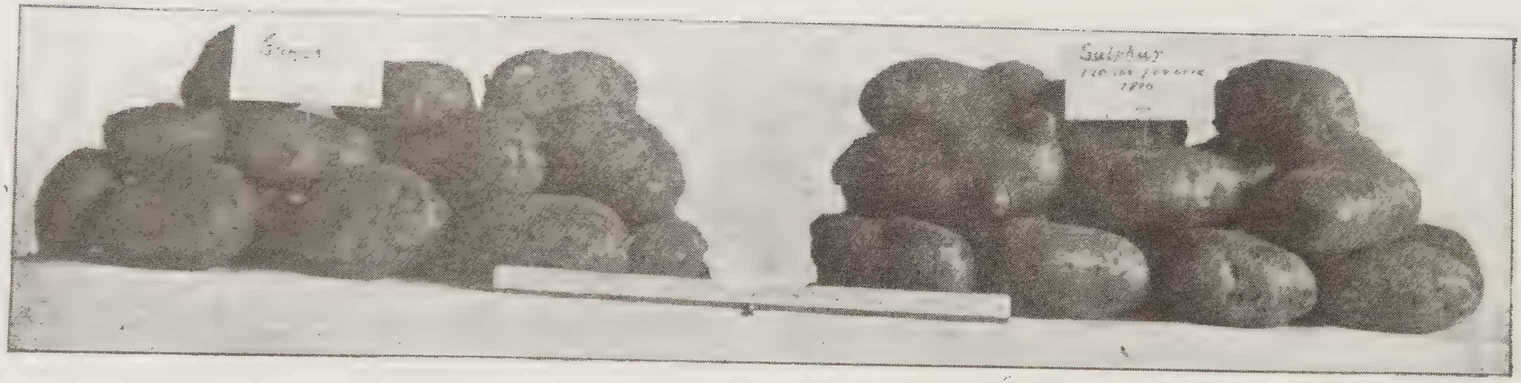

Fig. 17.
Potatoes grown with 120 pounds of Sulphur per acre, applied the present season.

In addition to the above, Figure 17 shows the contrast between the check and a belt receiving 120 pounds of sulphur per acre for the present year. The sulphur in this case was applied to a soil where the potatoes the season before were 100 per cent. scabby.

Further Experiments with Potatoes.

Opportunity offered in three plots for testing the value of different methods of cutting the "seed," and also of depths in planting. The three plots received the same treatment, but each was with a different

	Belt 1.			2.			3.			4.			5.			6.		
	Bud Ends.			Middles.			Stem Ends.			Middles.			Middles (Irrigated).			Middles (Depths).		
																8 in	6 in	4 in
Number of plants	20	18	20	20	20	20	20	17	20	21	21	21	19	19	20	19	21	21
Weight of plants	26.5	26	23	24	22	22	23.5	11	19	30	32.5	32.5	34.5	20	33	23.5	26	32
Weight of tubers	20.5	24.5	21	26.5	28	26	19	17.5	19	22.5	25	23.5	33	31	29.5	20	28	21.5
Weight of scabbed	20.25	24	17.5	26	28	25.5	18.5	15.5	16.5	19	23.5	22	20	24	23	18.5	23.5	18.5
Weight of unscabbed	.25	.5	3.5	.5	0	.5	.5	2	2.5	3.5	1.5	1.5	13	7	6.5	1.5	4.5	3
Total tubers by belts	66			80.5			55.5			71			93.5			69.5		

Fig. 18.

Results of Further Experiments with Potatoes—Early Rose.

variety of potato, the following being employed, namely, "Early Rose," "American Giants," and "Rural No. 2." The first belt in each plot was planted with the bud end of the potatoes; belt 2 with the

middle pieces, and belt 3 with cuts from the stem end. All the other three belts in each plot were planted with the middle pieces, and one belt (5) was irrigated; another (6) had the potatoes planted at different depths, while the remaining belt (4) was untreated. Mulch was applied to one row in each belt, and therefore the results are given in the table by rows, as well as by belts, three rows making a belt. The matter of the mulching is treated of under a separate general heading of this report.

	Belt 1.			2.			3.			4.			5.			6.		
	Bud Ends.			Middles.			Stem Ends.			Middles.			Middles (Irrigated).			Middles (Depths).		
																8 in	6 in	4 in
Number of plants......		18	20	18	20	20	15	19	15	20	21	18	17	19	21	13	18	17
Weight of plants......		4	6	10.5	6	9.5	6.5	9	6	12	18.5	10	13	11	16.5	11	11	4
Weight of tubers........	12.5	11	14	22	16	17	9	12.5	9.5	12.5	18	13	14.5	20	16	9.5	8	4.5
Weight of scabbed......	2	2	3	5.5	4	2	1	1	2.5	2	2.5	1.5	2.5	6	8.5	7.5	5	3
Weight of unscabbed...	10.5	9	11	16.5	12	15	8	11.5	7	10.5	17.5	11.5	12	14	7.5	2	3	1.5
Total tubers by belts..	37.5			55			31			43.5			50.5			22		

Fig. 19.

Results of Further Experiments with Potatoes—American Giants.

It will be seen that with the "Early Rose," the first variety to be harvested (August 5th), the greatest yield was upon the irrigated belt, and here also the potatoes free from scab are in excess of those upon

any other belts. The smallest yield was in the belt where the stem ends were planted, and in this plot all of the belts where the middle pieces were used the yield was better than in either the bud or stem-end belts.

In the depths belt, the row with seed planted six inches below the surface gave the best yield of the three depths tested, but it was no better than the rows of normal depth elsewhere in the plot.

	Belt 1.			2.			3.			4.			5.			6.		
	Bud Ends.			Middles.			Stem Ends.			Middles.			Middles (Irrigated).			Middles (Depths).		
																8 in	6 in	4 in
Number of plants.......	20	20	20	17	19	21	21	19	20	20	21	21	20	21	20	19	20	16
Weight of plants........	9.5	5	8.5	5	5	4.5	12	10.5	15.5	11	6.5	10.5	7	6.5	6.5	9	10.5	10
Weight of tubers.........	32	32	30	42	42.5	39	35	37	28.5	37	41.5	37	33	40	41.5	25	29.5	24
Weight of scabbed......	17	11.5	5.5	12.5	12	6	21.5	29.5	24	34.5	41.5	36.5	30.5	36.5	39	23	27	23
Weight of smooth.......	15	20.5	24.5	29.5	30.5	33	13.5	7.5	4.5	2.5	0	.5	2.5	3.5	2.5	2	2.5	1
Total tubers by belts..	94			123.5			100.5			115.5			114.5			78.5		

Fig. 20.

Results of Further Experiments with Potatoes—Rural No. 2.

The plot of "American Giants" was next harvested (August 14th) with a small comparative yield.

The largest yield was upon an unirrigated belt planted with middle pieces and the smallest yield was upon the depths belt, with the next

poorest where the stem ends were planted. In this plot the largest percentage of scab was upon the irrigated belt. No satisfactory results were obtained for either of the depths in planting.

The third plot, Rural No. 2, harvested August 26th, gave the largest yield of all the plots, and again the belts planted with middle pieces were ahead. The scab was greatest upon the check belt, followed closely by its adjoining belt under irrigation.

By taking the left-hand half of each of the three plots where the experiment of cutting the seed was carried out, it is seen that belt 2, where the middle portions of the seed potatoes were used, gives in each trial the largest yield.

	Bud End.	Middle.	Stem End.
Early Rose	66	80.5	55.5
American Giant	37.5	55	31
Rural No. 2	94	123.5	100.5
Totals	197.5	259	187

While there is no practical difference between the two ends, the uniform increase for the middle pieces would suggest that the end cuts might be discarded when the seed is prepared for planting.

If belt 2 is compared with the irrigated belt, the two being alike in all things save the water received, it is seen that the total yield is almost exactly the same, namely, belt 2, 259 pounds; irrigated, 258.5, while the scabbed potatoes are 123.5 and 190 pounds, or a very large increase of the diseased tubers on the irrigated belt.

The test with depths of planting does not give any indications of an advantage in varying from the normal depth. The results for the three plots for each depth are as follows:

	Depth, 8 inches.	Depth, 6 inches.	Depth, 4 inches.
Early Rose	20 pounds.	28 pounds.	21.5 pounds.
American Giant	9.5 "	8 "	4.5 "
Rural No. 2	25 "	29.5 "	24 "
Totals	54.5 pounds.	65.5 pounds.	50 pounds.
Total scabbed	49 "	55.5 "	44.5 "
Clean Potatoes	5.5 "	10 "	5.5 "

There is considerable additional labor in both the planting and harvesting where the depth is more than four inches, and the gain does not seem to justify the increase in cost.

Potatoes in the Turnip Land.

One of the belts in the land devoted to turnips was planted to Rural No. 2 to determine whether a long series of club-rooted crops f turnips would have any influence upon another widely dissimilar root" crop. The weight of tubers was 136 pounds, a larger yield than he same variety gave upon any belt elsewhere; but the most striking act obtained is that only a single pound was entirely free from the cab. Here is a case where land had not been in potatoes for at least ix years, and the crop was practically worthless.

EXPERIMENTS WITH SWEET POTATOES.

In 1895 experiments were made with sweet potatoes upon the farm f Mr. George W. Jessup, Cinnaminson, N. J., for the purpose of nding some preventive of the soil rot.* There were six series of plots n the field, three of them receiving fertilizers, namely, lime, manure, nd kainit, and three others alternating with these which received hemicals that it was hoped might check the soil rot, namely, sulphur, orrosive sublimate and copper sulphate. The arrangement of the xperiment offered an opportunity for combining the materials in airs and for leaving sufficient check plots. The accompanying plan Figure 21) shows the whole arrangement, and from it, it will be seen hat the first plot to the left, in each series, received the largest amounts f the substance; the middle row of plots (up and down), half those mounts, respectively, and a quarter as much was applied to the corresponding plots at the right end in each series. Combinations were nade between half-amounts in the row of plots lying between full nd half-amounts, and quarter-amounts were in combination in the lots lying between the half and quarter-amounts, as indicated in the headlines of the diagram. In Series I., the amount of lime was arge—a thousand bushels per acre in the left hand-plot.†

*For a consideration of this disease and engravings showing the trouble, the reader s referred to Bulletin No. 112, pages 13-20, and the Annual Report for 1895, pages 276–283.

†A young pear orchard had been set upon the land and the size and shape of the plots were modified thereby, each being one-thirtieth instead of one-fiftieth of an acre, as in the original plan. The materials to be used had been purchased and parceled out, so that the amounts in all plots were larger than originally contemplated.

	Full Amounts.		Half Amounts.		Quarter Amounts.
Series I. Lime.	Slaked lime, 1,000 bushels. Stand, 80 per cent. Yield, 19 pounds clean; 21 pounds marked.	**Check. Stand, 68 per cent. Yield, 17 pounds clean; 22 pounds marked.**	**Lime, 500 bushels. Stand, 75 per cent. Yield, 28 pounds clean; 24 pounds marked.**	Lime, 250 bushels; sulphur, 625 pounds. Stand, 65 per cent. Yield, 25 pounds clean; 12 pounds marked.	**Lime, 250 bushels. Stand, 98 per cent. Yield, 25 pounds clean; 18 pounds marked.**
Series II. Flowers of sulphur.	Sulphur, 2,500 pounds. Stand, 55 per cent. Yield, 47 pounds clean; 17 pounds marked.	Lime, 500 bushels; sulphur, 1,250 pounds. Stand, 15 per cent. Yield, 4 pounds clean; 5½ pounds marked.	Sulphur, 1,250 pounds. Stand, 70 per cent. Yield, 54 pounds clean; 11 pounds marked.	**Check. Stand, 60 per cent. Yield, 5 pounds clean; 49 pounds marked.**	Sulphur, 625 pounds. Stand, 94 per cent. Yield, 65 pounds clean; 38 pounds marked.
Series III. Manure.	Manure, 11 tons. Stand, 30 per cent. Yield, 1 pound clean; 12 pounds marked.	**Check. Stand, 30 per cent. Yield, 1 pound clean; 16 pounds marked.**	Manure, half amount. Stand, 58 per cent. Yield, 9 pounds clean; 31 pounds marked.	Manure, half amount; corrosive sublimate, 50 pounds. Stand, 55 per cent. Yield, 5 pounds clean; 32 pounds marked.	Manure, quarter amount. Stand, 60 per cent. Yield, 2½ pounds clean; 32 pounds marked.
Series IV. Corrosive sublimate.	**Corrosive sublimate, 200 pounds. Stand, 100 per cent. Yield, 57 pounds clean; 29 pounds marked.**	Manure, half amount; corrosive sublimate, 100 pounds. Stand, 85 per cent. Yield, 31 pounds clean; 28 pounds marked,	Corrosive sublimate, 100 pounds. Stand, 80 per cent. Yield, 61 pounds clean; 29 pounds marked.	Check. Stand, 55 per cent. Yield, 13 pounds clean; 35 pounds marked.	Corrosive sublimate, 50 pounds. Stand, 72 per cent. Yield, 29 pounds clean; 41 pounds marked.
Series V. Kainit.	Kainit, 5,000 pounds. Stand, 30 per cent. Yield, 9 pounds clean; 16 pounds marked.	**Check. Stand, 80 per cent. Yield, 19 pounds clean; 40 pounds marked.**	Kainit, 2,500 pounds. Stand, 70 per cent. Yield, 10 pounds clean; 35 pounds marked.	Kainit, 1,250 pounds; Sulphate of copper, 125 pounds. Stand, 40 per cent. Yield, 4 pounds clean; 27 pounds marked.	Kainit, 1,250 pounds. Stand, 40 per cent. Yield, 5 pounds clean; 28 pounds marked.
Series VI. Sulphate of copper.	**Sulphate of copper, 500 pounds. Stand, 60 per cent. Yield, 24 pounds clean; 28 pounds marked.**	Kainit, 2,500 pounds; sulphate of copper, 250 pounds. Stand, 75 per cent. Yield, 30 pounds clean; 33 pounds marked	Sulphate of copper, 250 pounds. Stand, 63 per cent. Yield, 12 pounds clean; 50 pounds marked.	**Check. Stand, 10 per cent. Yield, none clean; 15 pounds marked.**	Sulphate of copper, 125 pounds. Stand, 45 per cent. Yield, 15 pounds clean; 86 pounds marked.

Fig. 21.

Plan and results of Field Experiments for Soil Rot of Sweet Potatoes at Cinnaminson in 1895.

It was desired to determine how much lime the crop would bear, and the result shows that the poorest stand of plants in this series was in the plot where no lime was used, and adjoining the one receiving the largest amount. In the sulphur series, the stand of vines increases as the amount of sulphur diminishes, and it is not unlikely that the applications were too large, and, of course, such quantities were not expected to be practicable. The manure did not affect the stand materially, it being an unusually dry season, and at best the crop upon any plot in the whole field was small. With corrosive sublimate the stand was full with the plot receiving the largest amount and decreased as the quantity diminished. In the kainit and copper sulphate series no effect was recorded.

The potatoes at harvesting were all inspected and assorted into those marked with soil rot and those that were clean. No other form of rot was present in sufficient amount to enter into the problem.

The following table of averages was constructed, followed by averages of combinations, shown by the figures opposite the braces:

	Pounds of Clean Roots.	Pounds of Marked Roots.	Clean.	Marked.
Lime	25	21	15	8
Sulphur	55	22		
Manure	4	25	18	30
Corrosive sublimate	49	32		
Kainit	8	26	17	30
Sulphate of copper	18	40		
Check	9	29		

Two of the six series, namely, manure and kainit, give poorer results than the plot where nothing was used. Sulphur gives the highest yield of clean roots, followed closely by the corrosive sublimate. While the figures do not differ greatly, there are factors not to be stated by them; for example, the potatoes from the sulphur plots are very smooth and fair, free from scurf, crooks and disfigurements, while quite the opposite is true of those from the corrosive sublimate belts. Further, the cost of the sulphur is half that of the corrosive sublimate, to say nothing of the intensely poisonous, and therefore dangerous nature of the latter substance.

Experiments with Sweet Potatoes the Present Year.

The field of Mr. Jessup's, outlined above, was continued in sweet potatoes, this making the third successive crop attempted upon the land. The whole area was fertilized uniformly throughout, and no other additions were made to any plot, the point being to determine the lasting effects of the various substances that had been applied the previous year.

From the accompanying plan of results (Figure 22), some points of interest may be drawn. The season was a fair one as regards rainfall, and the crop was much larger than the previous year. There was, however, a decrease in the stand upon some of the plots, this being confined quite closely to those receiving the larger amounts of lime. Thus, the stand is lowest, 40 per cent., where the lime was 1,000 bushels, and only 55 per cent. where it was 500 bushels per acre the previous season. It was but little better, 60 per cent., where the 500 bushels were combined with 1,250 pounds of sulphur per acre, and but 75 per cent., far below the average, where lime was used at the rate of 250 bushels and sulphur 625 pounds per acre. Lime alone at the rate of 250 bushels reduced but little the stand of the plants.

Sulphur had no material effect upon the growth of the vines, the stand being 98 per cent. in all the three plots, and in short, in all the six series excepting lime, the treated plots averaged in the stand of plants as high as their checks.

The table of averages of clean and marked roots, constructed to correspond with that made for the previous year, is as follows:

	Pounds of Clean Roots.	Pounds of Marked Roots.	Clean.	Marked.
Lime	25	75	31.5	63
Sulphur	107	34		
Manure	89	54	63	83
Corrosive sublimate	83	72		
Kainit	80	79	94	59
Copper sulphate	63	48		
Checks	48	69		

This table shows two things at the first glance, namely, that lime is not a preventive of the soil rot, and that of all the substances tested sulphur is the best remedy for the disease.

	Full Amounts.		Half Amounts.		Quarter Amounts.
Series I. Lime.	Slaked lime, 1,000 bushels. Stand, 40 per cent. Yield, 5 pounds clean; 65 pounds marked.	Check. Stand, 90 per cent. Yield, 50 pounds clean; 70 pounds marked.	Lime, 500 bushels. Stand, 55 per cent. Yield, 30 pounds clean; 59 pounds marked.	Lime, 250 bushels; sulphur, 625 pounds. Stand, 75 per cent. Yield, 44 pounds clean; 65 pounds marked.	Lime, 250 bushels. Stand, 95 per cent. Yield, 40 pounds clean; 110 pounds marked.
Series II. Flowers of sulphur.	Sulphur, 2,500 pounds. Stand, 98 per cent. Yield, 81 pounds clean; 7 pounds marked.	Lime, 500 bushels; sulphur, 1,250 pounds. Stand, 60 per cent. Yield, 18 pounds clean; 61 pounds marked.	Sulphur, 1,250 pounds Stand, 98 per cent. Yield, 110 pounds clean; 50 pounds marked.	Check. Stand, 98 per cent. Yield, 70 pounds clean; 70 pounds marked.	Sulphur, 625 pounds. Stand, 98 per cent. Yield, 180 pounds clean; 46 pounds marked.
Series III. Manure.	Manure, 11 tons. Stand, 90 per cent. Yield, 50 pounds clean; 57 pounds marked.	Check. Stand, 80 per cent. Yield, 45 pounds clean; 83 pounds marked.	Manure, half amount. Stand, 90 per cent. Yield, 87 pounds clean; 65 pounds marked.	Manure, half amount; corrosive sublimate, 50 pounds. Stand, 95 per cent. Yield, 80 pounds clean; 46 pounds marked.	Manure, quarter amount. Stand, 98 per cent. Yield, 129 pounds clean; 40 pounds marked.
Series IV. Corrosive sublimate.	Corrosive sublimate, 200 pounds. Stand, 99 per cent. Yield, 79 pounds clean; 50 pounds marked.	Manure, half amount; corrosive sublimate, 100 pounds. Stand, 98 per cent. Yield, 45 pounds clean; 128 pounds marked.	Corrosive sublimate, 100 pounds. Stand, 98 per cent. Yield, 102 pounds clean; 61 pounds marked.	Check. Stand, 95 per cent. Yield, 56 pounds clean; 69 pounds marked.	Corrosive sublimate, 50 pounds. Stand, 98 per cent. Yield, 68 pounds clean; 102 pounds marked.
Series V. Kainit.	Kainit, 5,000 pounds. Stand, 85 per cent. Yield, 45 pounds clean; 62 pounds marked.	Check. Stand, 95 per cent. Yield, 43 pounds clean; 69 pounds marked.	Kainit, 2,500 pounds. Stand, 95 per cent. Yield, 81 pounds clean; 60 pounds marked.	Kainit, 1,250 pounds; sulphate of copper, 125 pounds. Stand, 85 per cent. Yield, 94 pounds clean; 52 pounds marked.	Kainit, 1,250 pounds. Stand, 90 per cent. Yield, 114 pounds clean; 86 pounds marked.
Series VI. Sulphate of copper.	Sulphate of copper, 500 pounds. Stand, 90 per cent. Yield, 60 pounds clean; 19 pounds marked.	Kainit, 2,500 pounds; sulphate of copper, 250 pounds. Stand, 98 per cent. Yield, 94 pounds clean; 66 pounds marked.	Sulphate of copper, 250 pounds. Stand, 95 per cent. Yield, 54 pounds clean; 69 pounds marked.	Check. Stand, 80 per cent. Yield, 22 pounds clean; 57 pounds marked.	Sulphate of copper, 125 pounds. Stand, 95 per cent. Yield, 75 pounds clean; 55 pounds marked.

Fig. 22.

Plan and results of Field Experiments for Soil Rot of Sweet Potatoes for 1896.

The totals, in pounds, of the several substances run as follows:

Lime	100
Lime and sulphur	94.5
Sulphur	141
Manure	143
Corrosive sublimate	155
Manure and corrosive sublimate	146
Kainit	159
Copper sulphate	111
Kainit and copper sulphate	153
Checks	117

By deducting 33⅓ per cent. from the "marked" roots, a fair representative of the marketable crop for each substance is as follows:

	Marketable. Crop.		Rank.
Lime	75	pounds.	7
Sulphur	118	"	1
Lime and sulphur	52.5	"	9
Manure	107	"	4
Corrosive sublimate	107	"	4
Manure and corrosive sublimate	91	"	5
Kainit	109	"	3
Copper sulphate	82	"	6
Kainit and copper sulphate	114	"	2
Checks	71	"	8

From this it is seen that only one substance falls below the check plots, namely, lime, whether it be alone or in combination with sulphur. The sulphur is closely followed by kainit when in combination with copper sulphate and third when alone. Manure and corrosive sublimate are equal, and when combined are nearly as good, the three sets forming the middle Nos. 4, 5 and 6 of the series of ranks, Copper sulphate alone gives nothing to encourage its use, and lime stands condemned as a preventive of soil rot.

The results of this second year show that there are marked differences in the properties of the compounds to check the soil rot. Sulphur maintains its first place and kainit has given results that warrant further experiments with it.

Upon the same field the coming year, some of the check plots will receive kainit and others kainit and sulphur combined, in the hope that with this a fertilizer-fungicide may be obtained that will be better than when either substance is used alone.

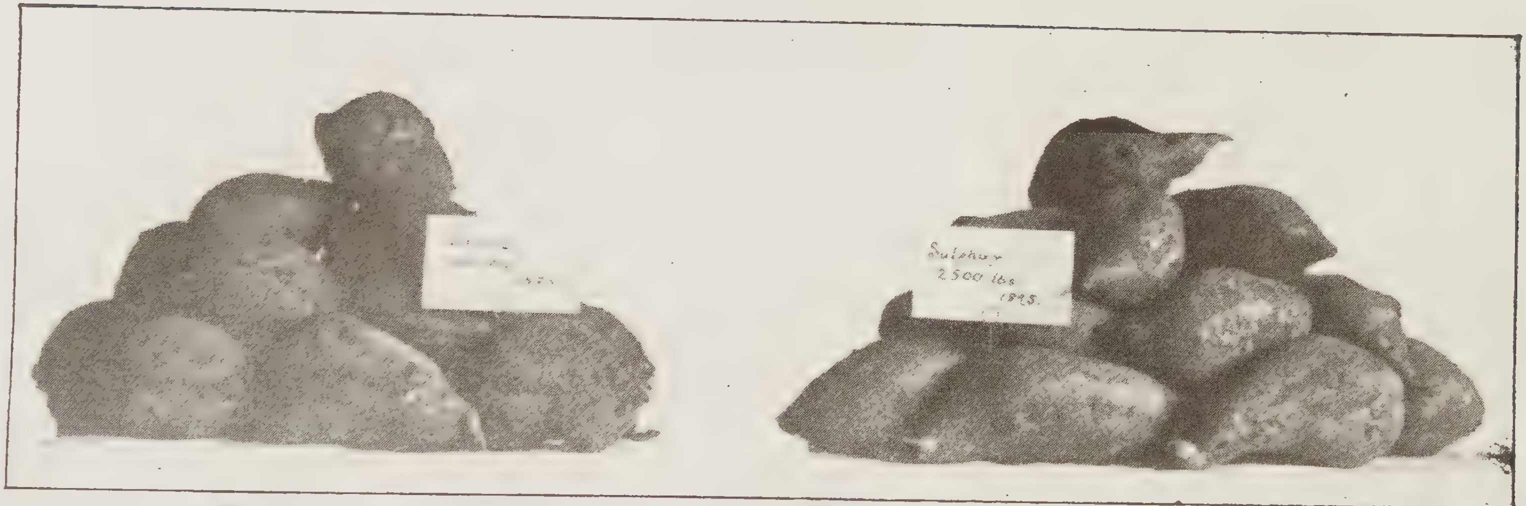

Fig. 24.
A larger view of the Lime and Sulphur belts.

Fig. 23.

From a photograph of the largest potatoes from Lime, Sulphur, Manure, Check, Corrosive Sublimate, Kainit and Sulphate of Copper belts.

Figure 23 shows the largest twenty-five sweet potatoes from seven of the plots, namely, where lime, sulphur, manure, check, corrosive sublimate, kainit and sulphate of copper were applied the previous year. This engraving corresponds with Figure 26 of the report for 1895. The two sets show almost parallel results, the roots from the limed ground being shorter than those produced elsewhere, while the fairest and best potatoes grew upon the plot receiving sulphur in 1895. The hold-over effect of the sulphur is more striking than that produced the first season.

A larger view of the piles from the sulphur and lime belts is shown in Figure 24, and corresponds with Figure 27 of the report of last year. The results for the two seasons upon the same pair of plots are similar.

Additional Experiments with Sulphur.

During the present season, three fields have been under experimentation with sulphur for the soil rot. Two of them have been in duplicate, located upon the adjoining farms of Mr. George W. Jessup and Mr. William Schmierer, Cinnaminson, N. J. The plan of the experiment was to apply sulphur in the row before setting the plants, in amounts ranging from 50 pounds to as high as 400 pounds per acre. The plots were four rows wide and sixteen rods long, each plot representing one-tenth of an acre.

The following are the results obtained upon the Jessup field:

	Clean Roots.	Marked Roots.
Sulphur, 50 pounds per acre	150	475
Check	375	375
Sulphur, 100 pounds per acre	750	256
Check	925	206
Sulphur, 200 pounds per acre	1,000	75
Check	975	137
Sulphur, 400 pounds per acre	1,075	50

The Schmierer field gave the following results:

	Clean Roots.	Marked Roots.
Sulphur, 50 pounds per acre	475	375
Check	325	375
Sulphur, 100 pounds per acre	425	475
Check	325	375
Sulphur, 200 pounds per acre	325	475
Check	225	375
Sulphur, 400 pounds per acre	525	300

Putting the two together the following figures are obtained :

	Clean Roots.	Marked Roots.
Sulphur, 50 pounds per acre	625	850
Check	700	750
Sulphur, 100 pounds per acre	1,175	731
Check	1,250	581
Sulphur, 200 pounds per acre	1,325	550
Check	1,200	512
Sulphur, 400 pounds per acre	1,600	350

A study of this last set of figures leads to the conclusion that the yield of clean roots increases with the increase of the amount of sulphur, namely, 625, 1,175 1,325 and 1,600 pounds ; on the other hand, the decrease of marked roots is constantly and uniformly in the same direction, namely, from 850, 731, 550 to 350 pounds.

In the plot experiments of two years' standing, previously described, the amount of sulphur did not fall in the lowest amount below 625 pounds per acre, and this supplemental test brings the amounts down through 400, 200 and 100 to 50 pounds. It would seem that the most profitable amount to use is between 200 and 400 pounds, or, in round numbers, 300 pounds.

In the present experiments the sulphur was placed in a fertilizer machine and scattered in the open row. The farmers in this neighborhood bought the sulphur in large quantities, fully 50 barrels, and it was procured for about $20 a ton or not far from a cent a pound. At that rate the cost of the sulphur, 300 pounds, and its application could not exceed $4 per acre. Taking the average of the three checks, 1,050 pounds, it gives 550 pounds of clean roots in favor of the plots receiving the 400 pounds of sulphur per acre, or 2,750 pounds for the whole acre. This is 110 baskets, counting 25 pounds to the basket, which at 25 cents a basket gives a net profit for the sulphur of $23.50 per acre, and when the price is 60 cents a basket, a profit of $62 per acre.

Another experiment was carried out upon the farm of Mr. Elmer Bradshaw, Mickleton, N. J., where the area was half that of the two above tests. The sulphur was mixed with a few times its own bulk of soil, and a small quantity thrown in the hole where the plant was to be set. The amounts per acre were the same as in the other experiments and the results were as follows :

Fig. 25.
Portion of plant showing the Stem Rot of Sweet Potatoes.

	Clean Roots.	Marked Roots.
Sulphur, 50 pounds per acre	25	81
Check	4	110
Sulphur, 100 pounds per acre	23	90
Check	5	85
Sulphur, 200 pounds per acre	20	70
Check	6	57
Sulphur, 400 pounds per acre	34	16

Here, while the yield was not large and the soil rot very bad, it is seen that all three checks did not together yield as many clean roots as any one of the treated plots. With so small a crop it is not easy to show that sulphur would pay, but there is unmistakable evidences of its wholesome effect shown in the table. If the marked roots are considered equal to two-thirds their weight of clean ones, the ratio between the average of the two plots receiving the largest amounts of sulphur and their separating check plot would be as 41 to 25. Had the crop here been equal to that of the other two experiments, the difference between the check and its adjoining treated plots would have been 125 baskets, or about $31 at 25 cents per basket—a net gain of $26 per acre for the sulphur.

In dollars and cents the experiments of the present season show a gain for sulphur of from $23.50 to $26 with potatoes selling at 25 cents a basket and an average of $50 if the selling price is 50 cents per basket.

The Stem Rot of Sweet Potatoes.

There has been more than a usual amount of the stem rot of the sweet potatoes, and Figure 25 is here introduced that growers may be aided in recognizing the trouble. This disease is due to a fungus that attacks the stem near the surface of the ground, causing it to decay. The vine is killed, and if the plant has made roots of some little size they may send up new shoots, but they do not amount to anything. The engraving shows an instance where the main stem has been girdled, but the secondary roots from the stems lying upon the ground have grown to some size and the vine still continues to live, but without any satisfactory results. No experiments with fungicides have been made and no remedy is suggested.

Sweet Potatoes Upon the Experiment Area.

A belt of four rows of sweet potatoes was grown alongside of Series VI. and between it and the ornamental grounds. A white, a yellow and a red variety were grown, with a view of testing this crop upon the soil of the experiment area, and noting any differences that might arise in the amounts of fungous enemies. The soil proved favorable for a rank growth of vines, but the roots were very inferior in shape and quality. None of the serious troubles, as black rot or soil rot, made their appearance, while the mildew appeared to some extent upon the foliage, and was in a measure controlled by all of the four fungicides employed. There were some differences in the yields, as the following figures show: White, 141.5 pounds; red, 202.5 pounds; yellow, 200.5 pounds.

EXPERIMENTS WITH BEANS.

During the two previous years (1894–95) Golden Wax beans have been grown, two crops each season, upon Plot I., Series V., of the experiment area. The same variety and two crops have been again raised upon the same land this season, thus making a total of six crops of the same kind upon the plot. The two enemies under consideration have been the anthracnose, or "Pod spot," due to the fungus *Colletotrichum legenarium* Pass. and the bacterial blight.

For the convenience of the reader the summary for the two previous seasons given in the report for last year is here reproduced in part.*

Summary for the Past Two Years.

The soaking in Bordeaux mixture of beans before sowing the seed does not check the development of anthracnose in the crop. Cupram in 1894 was found nearly equal to Bordeaux. In 1895 cupram was less effective.

Eau Celeste gave good results, followed closely by the "hydrate." Sulphate of copper used with soap, to cause the substance to adhere, gave results practically identical with the check belts, and when used

* A full consideration of the details upon which the summary is founded is given in the report for 1894, pages 294-300, and for 1895, pages 283-292, with engravings of diseases and plates showing some of the results.

without the soap, yielded the poorest returns of all substances. Sulphide of potassium, while tested only on a small scale, gave no indications of fungicidal properties with beans.

The third crop upon the same land showed over four times as much pod-spotting as the first crop grown at the same time upon adjoining new land. The total crop was somewhat larger upon the old land.

A test of irrigation with one belt of the second crop of 1895 showed that the yield of pods was more than doubled and the quality much improved. Upon the other hand, the spotted pods were increased fourfold, thus indicating that water in this instance does not act as a fungicide.

When the old spotted pods of a previous crop are placed upon a belt as a mulch, they will communicate the disease to the succeeding crop, the increase over normal belts being fourfold.

Four and a half inches in the row, with the rows twenty inches apart, seems to be the best distance for beans of the Golden Wax type.

The planting of the old bean plot was upon April 25th, and the belt contained the same number of rows (6) as formerly. In the cultural belt different depths of planting were tested in place of different distances of the year before. The following diagram (Figure 26) indicates the treatment for each of the belts:

Belt 1.	2.	3.	4.	5.	6.
Sprayed with soda-bordeaux. Row 6 mulched with excelsior.	Sprayed with Bordeaux. Row 1 mulched with excelsior.	Sprayed with potash-bordeaux. Row 6 mulched with marsh hay.	Check. Row 1 mulched with marsh hay.	Irrigated. Row 6 mulched with fresh hay.	Depths, 2 rows, 6 in. deep. 2 " 4 " 2 " 1 " Pods of previous crop applied to soil in Nov., 1895.

Fig. 26.
Plan of Bean Experiments for 1896.

An adjoining row, each, of the soda bordeaux and the Bordeaux belts, received a mulch of excelsior; in like manner the adjoining row of potash-bordeaux and check received marsh hay, and the corresponding rows in the irrigation and depths belts, fresh meadow hay as a mulch.

	Belt 1.	2.	3.	4.	5.	6.
Pods, sound	60.75 lbs.	76.5 lbs.	78 lbs.	67.5 lbs.	60.5 lbs.	41 lbs.
Pods, bacterial	6 pods.	18 pods.	8 pods.	4.5 "	2.5 "	.5 "
Pods, anthracnose	0 "	0 "	0 "	6.5 "	14.5 "	8.75 "
Total	61 lbs.	77 lbs.	78.25 lbs.	78.5 "	77.5 "	50.25 "
Tops	62.5 "	77.5 "	71.5 "	87.5 "	101 "	67 "
Grand total	123.5 "	154.5 "	144.75 "	166 "	178.5 "	117.25 "

Fig. 27.

Results of Bean Experiments upon Plot I., Series V., for First Crop in 1896.

It is seen that the anthracnose is absent from the sprayed belts, but is in considerable abundance elsewhere, the largest amount being in the irrigated belt, where the percentage was 18.70 and 8.28 per cent. in the check. This test illustrates the comparatively equal value of the three fungicides employed, and the effect of the irrigation, which more than doubled the amount of the pod spot above that of the check.

In the cultural belt, the 50 per. cent. increase of anthracnose over that of the check is to be set down to the undesirable effect of the old pods and refuse of the plot that were purposely placed upon this belt at the close of the harvest of the preceding crop.

The bacterial blight was almost absent from the sprayed belts, but showed itself to some extent in the check, 5.73 per cent., and less in the irrigated belt.

A glance at the total weights of the crop shows that the irrigated belt led, followed closely by the check, that was doubtless favored by its adjoining the watered belt. That the cultural belt was not equally affected will be apparent when the depths are studied in detail. Of the three sprayed belts, the Bordeaux gave the largest yield of both pods and tops, followed by the one receiving the potash-bordeaux.

One row in each belt was mulched, but not with the same material, and therefore the results are not comparable throughout. The results are given under the general heading of "Experiments with Mulch."

In the cultural belt the beans were planted as follows: Two rows, six inches; two rows four, and two rows, one inch deep. The results are given in the table below, brought to the terms of a whole belt for each:

Beans Planted.	6 Inches.	4 Inches.	1 Inch.
Pods	27.6 pounds.	45 pounds.	105.9 pounds.
Tops	30 "	60 "	105 "
Total	75.6 pounds.	105 pounds.	210.9 pounds.

Anything below one inch proved unwise, and the latter was better than an average of all the other belts in the plot, where the depth was two inches. The five belts at the normal depth gave an average of 155.9 pounds, while the one-inch-deep rows gave a yield per belt of 210.9, an increase of 73 per cent. There is a suggestion here that two inches is deeper than is best for planting beans, and somewhere between it and one inch may be better.

The Second Bean Crop for 1896.

A second crop of beans was planted upon the old bean land, Plot I., Series V., on July 17th, and was in all respects a duplicate of the first, except that mulching was omitted between the irrigated and the cultural belts. The following results were obtained at the harvest on September 25th :

	Belt 1.	2.	3.	4.	5.	6.
Pods, sound	35.5 lbs.	40.5 lbs.	44 lbs.	30.5 lbs.	34.5 lbs.	25 lbs.
Pods, bacterial	2.4 "	2.7 "	2.6 "	13.6 "	11 "	7.3 "
Pods, anthracnose	0 "	1 pod.	2 pods.	.75 "	9.25 "	2.5 "
Total	37.9 "	43.2 lbs.	46.6 lbs.	44.85 "	54.75 "	34.8 "
Tops	31 "	31 "	35 "	37.5 "	38.5 "	23 "
Grand total	68.9 "	74.2 "	81.6 "	82.35 "	93.25 "	57.8 "

Fig. 28.

Result of Bean Experiments upon Plot I., Series V., for Second Crop in 1896.

From the list of total weights it is seen that irrigation leads, followed closely by the check. Of the sprayed belts the potash-bordeaux is somewhat better in both pods and tops than the Bordeaux with the soda-bordeaux giving the same amount of tops as the Bordeaux, but a smaller yield of pods.

There was practically no anthracnose in the three sprayed belts, the exact record being two pods for the potash-bordeaux, one for the Bordeaux and none for the soda-bordeaux. A small percentage of the bacterial blight was present, but less in the soda-bordeaux belt than in the other two. The largest amount of disease was with the check, where nearly a third of the pods were spotted and a somewhat less amount appeared upon the beans under irrigation. The cultural belt shows a large amount of bacterial blight, and contained double the quantity of anthracnose found in all the other belts, due probably to the application of the diseased pods of the autumn before.

Beans Upon New Land.

Plot IV., Series III., previously in tomatoes for two years, was sown to beans in exact duplication of the plot above described, the leading thought being the comparison of new land with that having had two crops each for the two previous years.

The following are the results (Figure 29):

	Belt 1.	2.	3.	4.	5.	6.
Pods, sound..	68 lbs.	74 lbs.	62 lbs.	69 lbs.	49 lbs.	67 lbs.
Pods, bacterial	2 pods.	16 pods.	2.5 "	4.5 "	3 "	3 "
Pods, anthracnose....	0 "	16 "	4 pods.	3.5 "	4 "	2 "
Total....................	68 lbs.	75 lbs.	64.5 lbs.	76 "	56 "	72 "
Tops........................	75 "	80 "	72 "	80 "	72 "	81 "
Grand total.........	143 "	155 "	136.5 "	156 "	128 "	153 "

Fig. 29.

Results of Bean Experiments upon Plot IV., Series III., for First Crop in 1896.

It is seen from the table that the check gave the best returns, a fact that can be explained because of better land and the favorable conditions for moisture alongside of the irrigated belt. It is also possible that the fungicides had some unfavorable effect upon the beans. The irrigation was greatly in excess of the amount required, the purpose being to make a thorough test of water in its influence upon the health of the plants and the development of fungi. It is seen that the anthracnose was met with to a considerable extent, 7.32 per cent., upon the irrigated belt. Less than half, 3 per cent., of the amount was upon the check belt, still less upon the cultural (depths) belt, and upon the sprayed area it was almost entirely absent, sixteen pods showing it upon the bordeauxed belt, two pods upon the potash-bordeauxed belt, and none upon the soda-bordeauxed belt.

The bacterial disease was somewhat abundant, 5.36 per cent., upon the irrigation belt; a trifle less, 4.76 per cent., upon the check belt; still less, 2.79 per cent., upon the cultural belt, and almost none upon the sprayed portion, there being sixteen pods upon the bordeauxed belt, ten upon the potash-bordeauxed belt, and one pod upon the soda-bordeauxed belt.

The results in the cultural belt where depths of planting were tested are, in terms of a whole belt, as follows:

Beans Planted.	6 Inches.	4 Inches.	1 Inch.
Pods	51	67.5	91
Tops	63	96	84
Total	114	163.5	175

This shows that the one-inch depth is superior to the others and by comparison with the five belts in the plot, planted at the depth of two inches, that the yield of the one-inch planting is seen to be considerably above the average of 133.6 pounds, an increase of 76 per cent. This is almost the same increase that was found in the first crop upon the old bean land. In the second crop the rows planted one inch deep received such injury that they cannot be considered. As before stated, beans of the sort used upon the soil in hand may better be planted less than two inches deep.

No second crop of Wax beans was grown upon the new land, but instead, one-half of the rows were permitted to stand and mature their seed for use in the second crop upon the old land.

Three varieties of dwarf limas were sown in each belt, one row in place of each of the three alternate rows that had been harvested green. It was too late for any crop, but they were used for testing fungicides, and the results are given elsewhere under "Fungicides and Spraying."

EXPERIMENTS WITH TOMATOES.

An entire series was devoted to tomatoes in 1894. Six belts were sprayed with Bordeaux and the same number with cupram. The plants throughout the series were so little infested that no results of any importance followed from the use of fungicides. The yield obtained from a belt in which the plants were staked was not only considerably smaller, but the percentage of fruit rot was much greater than in adjoining belts in which the plants were allowed to remain upon the ground.

In 1895 two plots instead of four were assigned to tomatoes, and five of the belts in each plot were treated with fungicides, as indicated in the following table (Figure 30):

Plot III.	Sulphate of copper without soap.	Bordeaux.	Sulphate of copper with soap.	Check.	Eau Celeste without soap.	Potassium sulphide.
Plot IV.	Sulphate of copper with soap.	Bordeaux.	Sulphate of copper without soap.	Check.	Eau Celeste with soap.	Potassium sulphide.

Fig. 30.

Plan of Tomato Experiments for 1895.

There was a considerable increase in the percentage of leaf blight over that of the previous season, but outside of the cultural belt referred to below, none of the belts were seriously infested.

The results of the above experiments were summarized in the report of 1895 as follows:

"Only one fungicide gave any marked effect, namely, Bordeaux, which reduced the decay of fruits to one-half of that upon the check belts. Sulphate of copper and Eau Celeste, both with and without soap, were worthless, and no favorable results came from the use of sulphide of potassium. Pruning the vines to a single stalk and tying them to a stake greatly shortened the crop, both in amount and period of ripening. Old vines added to the land in the fall stimulated the next crop of tomatoes, but the plants soon became sickly and the fruit comparatively poor. Irrigation late in the season gave no important results."

Experiments in 1896.

Plot III. of Series III. was again devoted to tomatoes in 1896. The plan of the experiments introduced is given in the following table (Figure 31):

Belt 1.	2.	3.	4.	5.	6.
Sprayed with soda-bordeaux. Row 6 mulched with excelsior.	Sprayed with Bordeaux. Row 1 mulched with excelsior.	Sprayed with potash-bordeaux. Row 6 mulched with marsh hay.	Check. Row 1 mulched with marsh hay.	Irrigated. Row 6 mulched with fresh hay.	Tomato plants of previous crop piled upon ground over winter. Row 1 mulched with fresh hay.

Fig. 31.

Plan of Tomato Experiments for 1896.

The yield of each of the six belts is given below (Figure 32) in terms of ripe, green and spotted fruits. The green tomatoes were picked after the plants were destroyed by frost.

	Belt 1.	2.	3.	4.	5.	6.
Ripe	1,507	1,512	1,303	1,278	1,037	1,625
Green.	330	500	250	100	250	200
Spotted....	106	63	108	108	163	119
Total.....	1,943	2,075	1,661	1,486	1,450	1,944

Fig. 32.
Product of the Tomato Belts.

As above indicated, the percentage of spotted fruits was not large in any of the belts, but was somewhat lower in the sprayed than in the three unsprayed belts. As heretofore, the fruit rot was caused by the tomato anthracnose (*Glœosporium phomoides* Sacc.) The foliage of the tomato plants was much more seriously infested by leaf fungi the present season than was that of either of the two preceding crops. Two forms of leaf blight were conspicuous, namely, *Septoria lycopersici* Speg. and *Cladosporium fulvum* Cke., but much more injury was done by the first than by the last-named fungus.

Blighted leaves were found in the unsprayed belts before the fruit had begun to turn, and at the time when the first ripe tomatoes were gathered, July 21st, much of the foliage had been destroyed. The sprayed belts, at the same time, were not sufficiently infested to be at all noticeable, and continued comparatively uninjured by disease up to the time when they were destroyed by frost. The yield of the several belts as presented in Figure 32, while favorable to the fungicides, indicates in but a small degree the actual difference between the sprayed and unsprayed belts. A majority of the fruits from the untreated plants was, as a rule, smaller than were those from the sprayed, and inferior in quality, owing to the fact that the greater part of the foliage of most of the unsprayed plants had been destroyed, and they were thus unable to properly mature their fruits or to shield them from the sun.

Blight was manifest somewhat earlier in the belt upon which the old plants had lain during the winter, but in a short time all three of the unsprayed belts, of which number six was one, seemed to be equally infested by disease. The excessively large quantities of water

added to belt five resulted in materially diminishing the yield of fruits, a large number of which were cracked and worthless. The percentage of fruit rot was considerably higher in this belt, but the injury due to leaf blight was about the same as in the adjoining belts. Mulching served to keep the fruit cleaner, but otherwise was of no practical benefit.

Summary.

Tomatoes have been grown upon the same ground in the experiment area for the past three years. There was a material increase in the percentage of leaf blight in the second crop over that of the first, and a much greater increase in the third crop over that of the second, in consequence of which the fruits of the infested vines were reduced in size and were inferior in quality. The loss due to fruit rot has been unimportant, and has remained about the same for all three crops.

The fungicides, Bordeaux, soda-bordeaux and potash-bordeaux have thus far proved equally efficient as preventives of tomato leaf blight, and the fruits from the belts so treated have been superior in size and in quality to those from the unsprayed areas.

Tomatoes grown upon land upon which old tomato plants have remained during the previous winter are much more subject to attack from leaf fungi.

Irrigation the past season has given only negative results; the yield of the irrigated belt was lower than elsewhere, and a large percentage of the fruits were rendered worthless on account of cracking.

EXPERIMENTS WITH PEPPERS.

In 1895 Plots I. and II. of Series III. were devoted to peppers of the "Bullnose" variety. The experiments with fungicides in this crop were the same as those introduced in the tomato plots, a statement of which is presented in Figure 31. One of the bordeauxed belts was mulched with old hay.

The only form of disease present in this crop was a small percentage of the pepper anthracnose (*Colletotrichum nigrum* E. & Hals.) infesting the fruits, and upon which the various fungicides had no practical effect. A severe drought prevailed during the latter part of summer and autumn, and very striking results were obtained in the one belt

in which irrigation was introduced. The yield was nearly doubled and the fruits were plump and marketable, while those from the unirrigated plants were shriveled and undersized.

The product from the belt mulched and sprayed with Bordeaux was somewhat larger and of better quality than that from the unmulched bordeauxed belt.

Experiments in 1896.

Upon Plot I. of Series III. peppers were again grown in 1896. The plan of the experiments with the fungicides and mulches the present season was a duplicate of that introduced in the tomato plot and stated in Figure 31. The pepper plants and fruits of the previous crop were placed upon belt six in November, 1895, and the fruits were worked into the soil the following spring.

The small percentage of spotted fruits throughout the plot was somewhat larger than in the previous crop, and was alike uniform upon the sprayed and unsprayed belts. There was an abundance of rain throughout the season, and irrigation and mulching were therefore superfluous. The foliage of the plants so treated was noticeably of a lighter green than was that of the unmulched and unirrigated plants; but such treatment did not noticeably increase or diminish the yield. The belt to which the old plants and fruits were applied gave a larger yield of fruits than the average, but was no more infested by disease.

Summary.

The only fungus to be combated in the pepper crops of the past two seasons has been the fruit anthracnose, and upon this the fungicides have had no apparent effect. Irrigation in the dry season of 1895 greatly increased the yield of fruit and improved its quality. No results were obtained from irrigation during the present season. Mulching in a dry season seemed to be of some benefit, but was useless during a season of average rainfall.

EXPERIMENTS WITH EGG-PLANTS.

In 1895 two plots (Nos. III. and IV., Series IV.) were devoted to egg-plants of the variety known as the New York Improved. The chief purpose of the experiment was to prevent, if possible by the use

of fungicides, the common egg-plant leaf spot and fruit rot caused by the fungus *Phyllosticta hortorum* Speg. The plan of the experiments was as outlined in the following table:

Plot III.	Sulphate of copper without soap.	Bordeaux. Mulched.	Sulphate of copper with soap.	Check.	Eau Celeste without soap.	Potassium sulphide.
Plot IV.	Sulphate of copper with soap.	Bordeaux.	Sulphate of copper without soap.	Check.	Eau Celeste with soap.	Potassium sulphide.

Fig. 33.
Plan of Egg-plant Experiments for 1895.

Eight applications of the several fungicides were made at intervals of about ten days. The product of each belt, in terms of sound and decayed fruits, is given below:

Plot III......	Sound.........	15	75	17	10	24	6
	Decayed......	30	28	35	44	38	40
	Total.......	45	103	52	54	62	46
Plot IV........	Sound	14	45	20	31	15	9
	Decayed	46	49	64	33	25	77
	Total	60	94	84	64	40	86

In the following table is indicated the percentage of decayed fruits in each belt:

Plot III...........	66.66	27.18	67.30	81.48	61.28	86.95
Plot IV..	76.66	52.12	76.19	51.56	62.50	89.53

As summarized in the report for 1895 the results of the season's experiments with egg-plants were as follows:

"The leaf spot and fruit rot of the egg-plant can be materially checked with fungicides. Of the several that were used, Bordeaux only, gave satisfactory results.

"Eau Celeste seemed to have no effect, while sulphate of copper, either with or without soap, gave poorer returns than the belts where nothing was applied.

"Sulphide of potassium failed entirely, and the belts receiving it were remarkable for the large per cent. of decay.

"Mulching egg-plants proved successful, in that the belt receiving a covering of old hay gave not only the largest yield of all, but far less of the decay than elsewhere."

In 1896 but one plot (No. III. of Series IV.) was assigned to egg-plants, and this plot was one of the two upon which egg-plants had been grown the previous year.

The plan of the experiments with the crop, as outlined in the following table, was the same as that introduced in the tomato and pepper plots:

Belt 1.	2.	3.	4.	5.	6.
Sprayed with soda-bordeaux. Row 6 mulched with excelsior.	Sprayed with Bordeaux. Row 1 mulched with excelsior.	Sprayed with potash-bordeaux. Row 6 mulched with marsh hay.	Check. Row 1 mulched with marsh hay.	Irrigated. Row 6 mulched with fresh hay.	Plants and fruits of previous crop piled upon ground over winter. Row 1 mulched with fresh hay.

Fig. 34.
Plan of Egg-plant Experiments for 1896.

Each of the three sprayed belts received fourteen applications of its particular fungicide at intervals of about ten days. The first application was made May 25th, and the last September 30th.

Under the head of "Irrigation of Garden Crops" and "Mulching of Garden Crops" will be found a statement of the outcome of the experiments conducted along those lines in connection with egg-plants.

The conditions prevailing during the past summer, namely, abundant rain and extreme heat, were alike favorable to the egg-plants and to the fungi preying upon them. For the first three or four weeks after the fruit began to develop, the sprayed belts were noticeably freer from disease than the unsprayed, but before much of the fruit had attained a marketable size the product of the sprayed belts was seen to be infested to essentially the same degree as the unsprayed. The presence of the fungus was first manifest upon the leaves, and later upon the calyx or stem-end of the fruit, from which it soon spread to the fruit itself. Not more than one-third of the fruits, whether in sprayed or unsprayed belts, attained a marketable size.

Several plants in each belt were destroyed this season by a stem disease, occasionally observed in the crop of 1895. This malady seemed unaffected by any of the fungicides.

In belt 6, upon which the old plants and fruits of last year were piled over winter, the percentage of fruit rot was very much higher than elsewhere; in fact, but two fruits in the entire belt attained a marketable size. A larger number of plants were also destroyed by the stem disease in this belt than in any of the other belts.

Summary.

The experiments with egg-plants for the past two seasons indicate that when this crop is grown upon land not recently devoted to that crop, the percentage of fruit rot may be largely prevented, as it was in 1895, by treating the plants with the Bordeaux mixture. When grown under the above conditions, good results may likewise be expected to follow from the use of soda-bordeaux and potash-bordeaux.

The growing of two successive crops of egg-plants upon the same land is believed to be inadvisable, since the fungous diseases peculiar to this crop seem likely to accumulate to such an extent as to be beyond the preventive power of fungicides unless applied with greater frequency than may be practicable.

EXPERIMENTS WITH CUCUMBERS.

In 1895 a well-known variety of cucumber, "White Spine," was grown upon Plots III. and IV. of Series V. The treatment of the vines in the several belts is indicated in the following table:

Plot III.	Sulphate of copper without soap.	Bordeaux. Mulched.	Sulphate of copper with soap.	Check.	Eau Celeste without soap.	Potassium sulphide.
Plot IV.	Sulphate of copper with soap.	Bordeaux.	Sulphate of copper without soap.	Check.	Eau Celeste with soap.	Potassium sulphide.

Fig. 35.
Plan of Cucumber Experiments for 1895.

The cucumber crop is usually more or less injured by two forms of fungous disease, the one a mildew (*Plasmopora Cubensis* B. & C.) infesting the foliage, and the other an anthracnose (*Colletotrichum legenarium* Pass.), which attacks both foliage and fruit. Each of the

diseases was sufficiently abundant in the check belts, and in some of the sprayed belts, to materially reduce the yield of fruits.

The results of the cucumber experiments of 1895 were summarized as follows:

"Cucumbers may be treated with fungicides for the anthracnose and mildew with reasonable hope of success. Bordeaux was the best substance employed in these experiments, and it not only increased the yield largely, but preserved the fruit from rotting. The bordeauxed plants were noticeably freer from the attack of the cucumber beetle than those in the remaining belts. Sulphate of copper, in a less degree than Bordeaux, gave favorable results in both the above points. Eau Celeste was third-rate as a fungicide, and sulphide of potassium failed to surpass the checks. Mulching is useful in preventing decay of fruits. Pruning the vines shortened the crop, without any compensating gains."

Experiments for 1896.

The present season, Plot III. of Series V. was again planted to cucumbers, and a second plot (IV. of Series IV.), upon which cucumbers had not been grown for at least six years, was also devoted to the same crop.

The plan of the experiments in the cucumber plot of Series V. is indicated in the following table. With the exception of mulching, the same experiments were introduced in the cucumber plot in Series IV.:

Belt 1.	2.	3.	4.	5.	6.
Sprayed with soda-bordeaux. Row 2 mulched with excelsior. Yield, 114 fruits.	Sprayed with Bordeaux. Row 1 mulched with excelsior. Yield, 134 fruits.	Sprayed with potash-bordeaux. Row 2 mulched with marsh hay. Yield. 125 fruits.	Check. Row 1 mulched with marsh hay. Yield, 65 fruits.	Irrigated. Row 2 mulched with fresh hay. Yield, 55 fruits.	Fruits of previous crop worked into soil. Row 1 mulched with fresh hay. Yield, 71 fruits.

Fig. 36.
Plan of Cucumber Experiments for 1896.

There was no difference in the treatment of the two plots, except that one row of plants in belts 5 and 6 of Plot III. of Series V. received a mulch of fresh hay as indicated above.

The striped cucumber beetle, somewhat harmful in 1895, was much more so the present season, and began its attack upon the young plants before they were well out of the ground. The experiment was thus seriously interfered with at the outset, for the number of plants in the several belts was unequal, and although the vacant hills were replanted, the difference remained essentially the same, since the younger plants being preferred to the older ones, were most of them destroyed. Air-slaked lime, usually a repellant of this pest, seemed to have little or no effect in this instance. The unsprayed plants were destroyed earlier in the season than were the sprayed, the beetle evidently being repelled to some extent by the fungicides. But after destroying most of the unsprayed plants, the sprayed were infested as the others had been, and by the middle of July most of the vines in all the belts, whether sprayed or unsprayed, were destroyed.

Under such circumstances it was impossible to make any satisfactory comparisons as to the relative amount of blight in the treated and untreated belts. In Series V., where cucumbers had been grown the preceding season, the leaf blight was more manifest than in the crop upon the new ground in Series IV. So far as observed, the only form of blight present was the anthracnose. The sprayed belts were all of them noticeably blighted, but to a less degree than the checks. There was a manifest difference in favor of the two belts sprayed with potash-bordeaux, while the soda-bordeauxed belts seemed to be infested somewhat less than the two treated with Bordeaux.

Had not the vines been destroyed by insects, it is reasonable to suppose that the differences in the relative amount of blight which were beginning to be manifest in July would have become much more pronounced by the end of the season.

One of the plots, that of Series V., was harvested August 8th. The cucumbers at this time were just beginning to ripen, and nearly all were sound. It will be seen from the table (Figure 36) that the yield from the sprayed belts was more than double that from the unsprayed.

The difference in yield must be attributed chiefly to the greater immunity of the seedling plants in the sprayed belts from insect attack, for, as already stated, the vines were everywhere destroyed before the blight had begun to seriously affect the crop.

Most of the vines of the plot in Series IV. were destroyed by

insects as early in the season as those upon the plot just considered. The fruits, however, were not harvested until a month later than those of Series V., but were allowed to remain upon the ground and ripen. The three fungicides continued to be applied to their respective belts as before.

When harvested, September 9th, the yield, in terms of sound and unsound fruits, was as stated in the following table (Figure 37):

	Belt 1.	2.	3.	4.	5.	6.
Sound	127	60	133	27	14	7
Decayed	40	14	30	35	27	65
Percentage of fruit rot.	23.9	18.9	18.4	56.4	65.8	90.2

Fig. 37.

Results of Cucumber Experiments upon Plot IV., Series IV., for 1896.

The percentage of fruit rot is also given for each of the belts.

The difference in yield in favor of the sprayed belts must be assigned, as in the cucumber plot of Series V., to greater freedom from insect attack, but the very decided decrease in the percentage of diseased fruits in the sprayed belts must be attributed entirely to the fungicides. The proportion of fruit-rot in the belts sprayed with Bordeaux and potash-bordeaux was almost the same, and was about five per cent. lower than in the soda-bordeauxed belt. The fruit rot was due in part to the anthracnose and also to what seemed to be a bacterial decay.

Summary.

Bordeaux, in 1895, greatly increased the yield in the belt to which it was applied, and diminished in like degree the percentage of fruit rot. During the present season the value of the mixture as a leaf fungicide was but imperfectly determined, owing to the early destruction of the vines. Its belt was freer from blight than the checks, but was infested somewhat more than the soda-bordeauxed, and decidedly more so than the potash-bordeauxed belt. During both seasons Bordeaux has greatly lessened the percentage of fruit rot.

Soda-bordeaux was used in 1896 for the first time as a preventive of cucumber diseases, and seemed somewhat more effective as a preventive of leaf blight than Bordeaux, and less efficient than potash-

bordeaux. The percentage of fruit rot in the belt so treated was about five per cent. higher than in either of the other two sprayed belts.

Potash-bordeaux was likewise used in cucumber experiments for the first time in 1896. Up to the time the crop was destroyed by insects the vines treated with this mixture were noticeably freer from leaf blight than those sprayed with either of the other two fungicides. The percentage of fruit rot in the potash belt was practically the same as in the one sprayed with Bordeaux.

The experiments of 1896 demonstrate that none of the fungicides employed can be relied upon to protect cucumber vines from the attacks of the striped beetle, although when so treated such vines are much less subject to attack than are adjacent unsprayed ones.

EXPERIMENTS WITH CELERY.

Plots I. and II. of Series IV. were planted with "New Rose" celery in 1895.

Each belt contained two rows of plants; every alternate row was irrigated from the time the crop was set out until about the first of November. The results obtained were summarized in the report for 1895 as follows:

"While there was no large amount of blight, the experiments show that the Bordeaux belts gave both the largest yield of crop and the least percentage of destruction by the fungus. 'Hydrate' came next, followed by cupram.

"The non-irrigated row in each belt showed a larger percentage of blight than the watered one.

"Irrigation gave satisfactory results, it, in round numbers, increasing the marketable crop in pounds threefold, and the value about eight times."

Experiments for 1896.

Another variety of celery, "Boston Market," was grown in 1896 upon Plot IV. of Series VI. It is probable that celery had never been grown upon this spot, certainly not within the last seven or eight years. The plants in belts 1, 2 and 3 were sprayed with soda-bordeaux, Bordeaux and potash-bordeaux respectively. Belts 4, 5 and 6 were unsprayed. Each belt contained two double rows, and it

was proposed to sub-irrigate, by means of loosely-laid tiles, the second row in each of the first three belts, and to surface-irrigate the second rows in the last three belts. Irrigation was begun, but discontinued shortly after, since more than the required amount of moisture was supplied by frequent rains. The plants in all the belts were almost wholly free from blight, and no results were, therefore, obtained from spraying. The crop is upon the ground at the time of writing.

EXPERIMENTS WITH PEAS.

Experiments with the diseases of peas, particularly the leaf blight (*Ascochyta Pisi* Lib.) and the pea mildew (*Erysiphe Martii* Lev.), were not undertaken until the present season, when one plot (IV. of Series V.) was sown to a quick-growing sort—the "First of All." The first crop was not sprayed, the hope being that the fungous diseases might accumulate upon the plot so that in the future there would be ample opportunity for using fungicides. One of the six belts was irrigated, and in another the depths of sowing varied from the normal. There was so small an amount of blight that no account was made of it. The crop was left upon the vines until the average pods were about midway between the plump green and the mature condition, when the vines were pulled and the pods removed. The following is the table of results for each of the belts:

	Belt 1.	2.	3.	4.	Irrigated. 5.	Depths. 6.
Pods	30.5	26	23.5	33	45.5	25
Vines	18.5	13	8.5	13	33.5	18.5
Totals	49	39	32	46	79	43.5

From this it is seen that there were large gains for the irrigated belt, arising from the fact that there was a dry spell when the plants first started into growth. The results for the rows with different depths of sowing are given elsewhere under the general title of "Depths of Planting."

The plot was again sowed to peas upon June 27th, the same variety being used, and from the package that was purchased for the first sowing. Two of the six rows in each of the belts were sown with seed from the first crop, that the old and fresh seed might be compared. In addition to this, soil applications were made of sulphur, corrosive sublimate, carbonate of lime and copper sulphate to half belts, with

the hope of checking the disease that comes upon the stems of peas close to the ground. Irrigation was continued upon belt 5 and different methods of sowing were employed upon belt 6, namely, two rows were sown 4 inches deep, two 2 inches deep and hilled up 2 inches, and the remaining two hilled up 4 inches. In harvesting this crop, a small one, the weights of the pods and vines were kept together, and as yet no account was taken of any slight differences in the blight. The figures are given in terms of whole belts :

	Sulphur.	Corrosive Sub.	Carb. Lime.	Copper Sulphate.	Check.	Irrigation.	Depths.
Weight of pods and vines..	11	14.6	19.4	11	14.2	13	12.7
Old seeds..........................	6.2	10.3	19.3	20.5	20.8	13.2	13.6
Fresh seeds........................	18.2	21.2	20	19.4	19	15	19

It will be seen that the largest yield is with carbonate of lime, and the least with sulphur and copper sulphate. The fresh seeds averaged much better than the old seeds.

The third crop is still upon the ground at time of writing, and shows excellent effects for Bordeaux in keeping off the diseases of the late crops of peas.

EXPERIMENTS WITH BEETS.

The one-fifth acre devoted to beets in 1896 had been a part of a field upon which two successive crops of mangel-wurzels had been grown in 1894 and 1895. The same variety, "Colossal Long Red," was again sown the present season. The primary experiment in connection with this crop consisted in spraying the foliage with the four fungicides described under "Fungicides and Spraying," to prevent the development of the common beet leaf blight, *Cercospora beticola* Sacc. Figure 38 shows the appearance of a beet leaf that is badly infested with the *Cercospora*. This fungus materially injured the two preceding crops, and its re-appearance could be expected with some degree of certainty.

The field was divided into six plots, the first of which was sprayed with soda-bordeaux, while the second was untreated. Plots III. and IV. were sprayed with Bordeaux and potash-bordeaux respectively, while V. was untreated, and to VI. was applied the ammonia-bordeaux. The date of the first spraying was June 6th, when the beet seedlings were about one month old, and the crop was sprayed twelve

times, the last application being made September 14th. The intervals between sprayings ranged from six to fourteen days, the time varying according to the amount of rainfall. Heavy and frequent rains, with high temperatures, prevailed during June and July, and greatly favored the development of the leaf spot. At the same time the above conditions tested thoroughly the fungicidal properties of the several solutions employed, the efficiency of which must have been materially diminished by the washing of the rains.

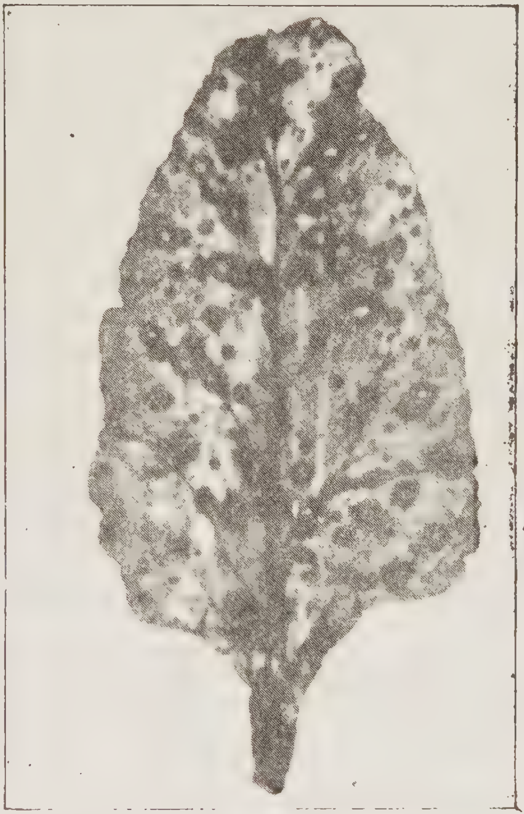

Fig. 38.
Lear badly spotted with the *Cercospora beticola* Sacc.

Little or no blighting was observed during the first four or five weeks after the appearance of the young plants, but from that time, however, the characteristic discolorations began to be noticeable and the disease made rapid progress everywhere except in the sprayed plots, which continued comparatively uninfested. By July 1st there was a decided contrast between sprayed and unsprayed plots, and the difference became more pronounced during the following ten or twelve weeks, that is, up to the first of September. Only a small proportion of the foliage of the sprayed plants was injured by blight, whereas that of the unsprayed was reduced for the most part to the more recently-developed leaves, the older leaves hanging down shriveled and lifeless. A second form of blight (*Phyllosticta* sp.) was occasionally observed during the months of June and July, but later in the season it seemed to have wholly disappeared. Ammonia-

Plot III., sprayed with Bordeaux, compared with the same check, shows an increase of 98 per cent. and in the amount of roots of 66 per cent. In this instance the advantage from soil fertility is somewhat in favor of the sprayed plot, but when it is compared with the second check, Plot V., the reverse is true. The difference in yield, although less than with the first check, is yet decidedly in favor of the lime plot, the amount of foliage being greater by 60.5 per cent., with an increase in roots of 31 per cent. Compared with the average of the two checks, the Bordeaux plot shows an increase of 77.5 per cent. in amount of foliage and 46.5 per cent. in roots.

Still more favorable results followed the application of potash-bordeaux in Plot IV. Here the increase in foliage over the adjoining check, Plot V., was in foliage 78.5 per cent, and in roots 47.5 per cent. The difference as to soil fertility was in favor of the check. Compared with the yield in the first check the per cent. of increase is considerably greater than in case of the Bordeaux plot. The weight of foliage was more than double that of the check, 121.5 per cent., while the roots showed an increase of 87 per cent. The gain of the potash belt over the average of the two checks was, for foliage 97.5 per cent. and for roots 65 per cent.

In Plot VI., sprayed with ammonia-bordeaux, there was a gain in foliage over the adjoining check of 28.5 per cent., but the weight of roots was less by 14 per cent.

As already stated, this plot occupied the most fertile soil in the series, but owing to the foliage having been greatly injured by the burning of the fungicide, it was only to be expected that the product would be much below the normal. That the injury was due to the fungicide rather than to the fungus was apparent, since the spotting of the latter was not sufficient to produce any appreciable harm to the plants.

Scab Upon Beets.

In the bulletin upon diseases of beets above referred to, mention is made of the identity of the scab of the potato and beet. In the spring a quantity of scabbed potatoes was placed upon a small portion of the beet ground. At harvest time nearly all of the roots were more or less scabbed, while elsewhere there was but a very small per cent. of the trouble, and the unity of the potato and beet scab was established by field inoculation.

A second method of verification was adopted in that one of the belts of the series upon which thoroughly-scabby potatoes had been grown the previous season was sown to beets of several varieties.

All were badly affected with the scab, there being a larger percentage upon the round than the long sorts. This was due to the fact that the fungus was more active near the surface of the soil than elsewhere. Figure 41, made from a photograph of a long beet, illustrates the fact that the scabs are generally confined to a zone of about three inches, beginning an inch or so below the surface. In no case were any beets in the beet series outside of the area receiving the scabby potatoes so badly scabbed as those that were grown in the land after scabby potatoes. The proof is quite conclusive that the disease is the same in both beet and potato, and the practical point is enforced that one of these diseased crops should not follow the other.

EXPERIMENTS WITH SUNFLOWERS.

A row of sunflowers (*Helianthus annuus* L.) of the ordinary sort, grown for its seed for farm use, was sown alongside of the field of beets. The chief point in the experiment was to make a test of four spraying mixtures for the rust (*Puccinia tanaceti* D. C.), a disease that is abundant upon the sunflowers in the State. The sunflower is also affected with a stem trouble due to a fungus (*Phlyctæna* sp.), closely related to the serious stem blight of the cosmos.

The row of sunflowers received the sprayings according to the plan given below:

Am.-Bordeaux. Check. Potash-Bordeaux. Bordeaux. Check. Soda-Bordeaux.

The rows were 138 feet long and each belt, therefore, twenty-three feet wide, with the plants a foot apart in the row.

There were twelve sprayings, and at the close of the season the results were obtained by selecting the largest five plants in each of the six sections. From these chosen plants the leaves were all divided into the living ones and those that were dead.

	Live Leaves.	Dead Leaves.
Soda-bordeaux	71	56
Check	70	55
Bordeaux	71	57
Potash-bordeaux	27	72
Check	40	68
Ammonia-bordeaux	13	82

Fig. 41.
A beet illustrating the zone of Scab midway between top and bottom.

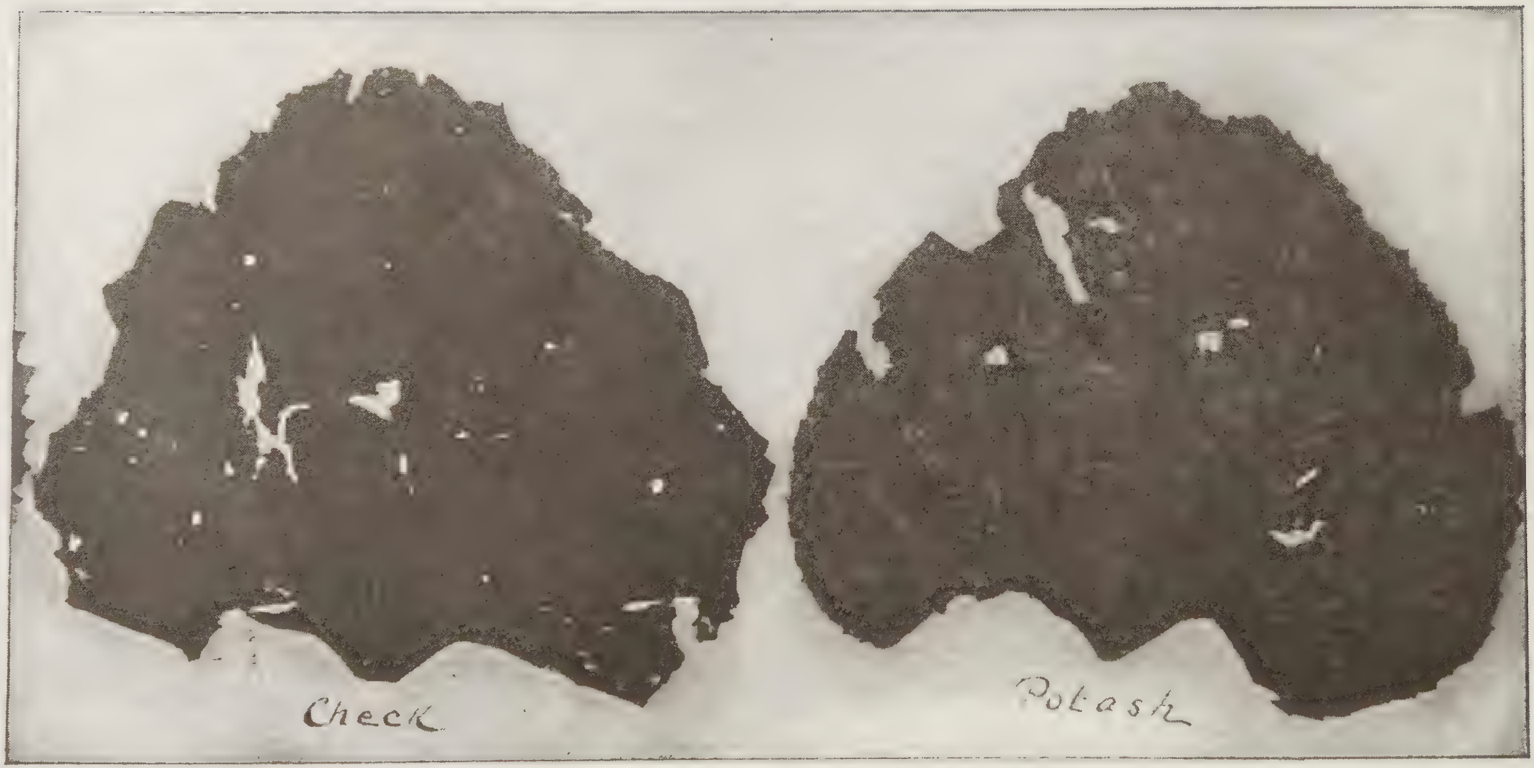

Fig. 43.
A larger view of the Leaf sprayed with the Potash-Bordeaux and a Check.

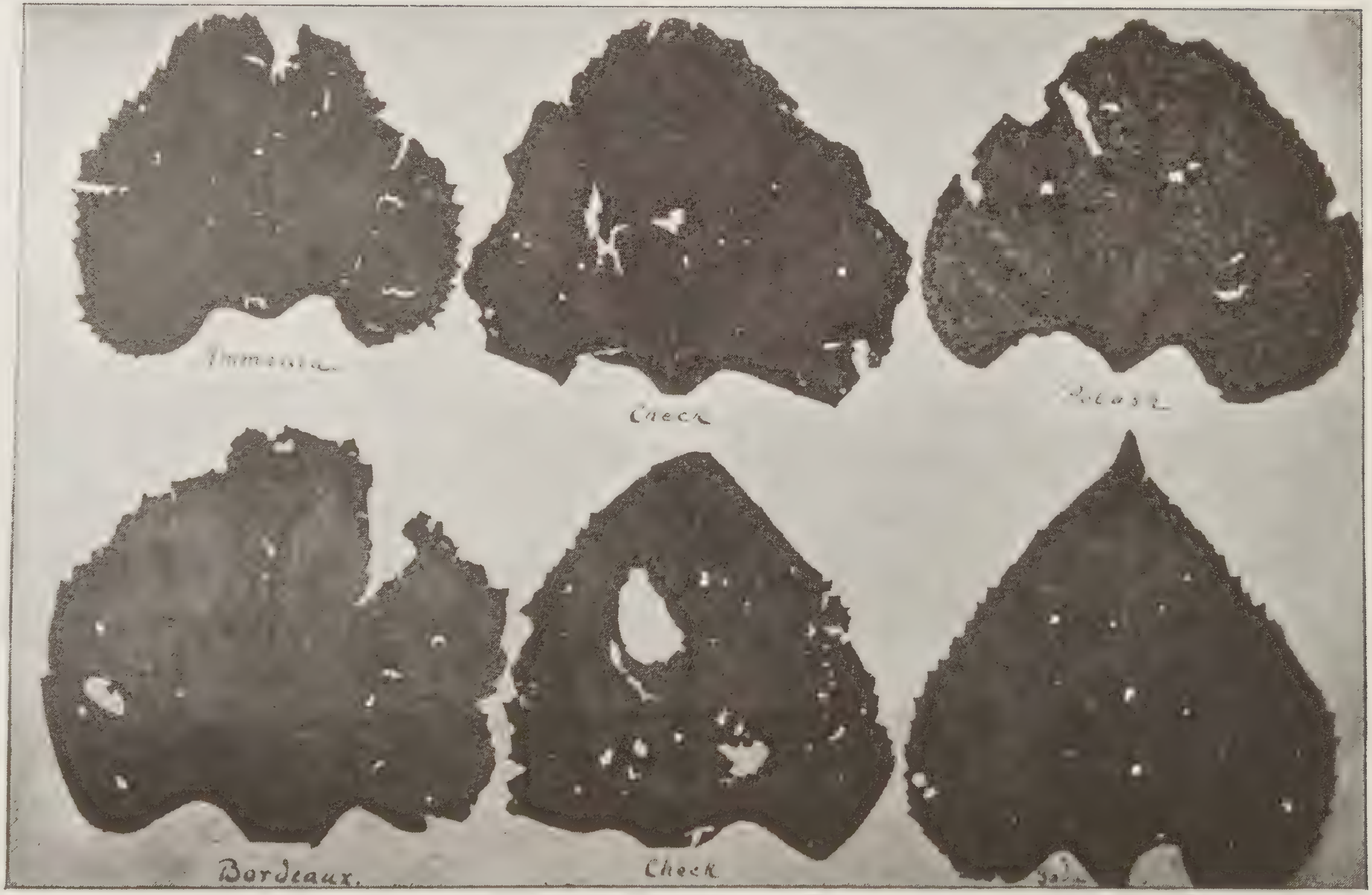

Fig. 42.

Six Sunflower Leaves, showing the effects of the four Fungicides upon the Rust.

This table shows that the ammonia-bordeaux gave the least number of live leaves and the potash-bordeaux next, with two checks occupying a middle position in the scale, and exceeded by the Bordeaux and the soda-bordeaux. These figures, while they give the rate of maturing of the foliage, do not prove to be an index of the amount of rust upon the plants.

To determine the relative rustiness of the foliage the following plan was adopted: The worst five rusty leaves were selected from the five best plants, and from these five the average leaf was taken in each section. Upon these the pustules (sori) of the rust were counted with the following results in terms of pustules per square inch of leaf surface:

	Number of Pustules.
Soda-bordeaux	36
Check	213
Bordeaux	25
Potash-bordeaux	27
Check	242
Ammonia-bordeaux	2

From this table it may be seen that all of the fungicides were active in keeping down the number of spore spots. Upon the leaves receiving the ammonia-bordeaux almost no rust made its appearance, while with the soda-bordeaux the amount was less than a sixth that shown by the average of the checks. There was but a trifle of difference between the results with the Bordeaux and the potash-bordeaux, there being less than an eighth of that shown upon the checks.

No satisfactory results were obtained in the attempt to check the stem blight (*Phlyctæna*), and this accounts for the apparent discrepancy between the two tables of results above shown. In short, the stem blight attacked the plants indiscriminately, and thus made serious inroads upon a plant whether it was rusted or not, sometimes breaking it down prematurely.

Figure 42 shows six sunflower leaves with the effects of four fungicides upon the rust. In Figure 43 is given a larger view of a leaf sprayed with the potash-bordeaux along with one from a check section of the experiment row of sunflowers.

EXPERIMENTS WITH ONIONS.

While there is but very little onion smut (*Urocystis cepulæ* Fr.) in the State, there have been calls for experiments from some localities. Smutted onions were obtained through the kindness of Dr. Sturges, of the Connecticut Experiment Station, and Professor Seymour, of Harvard University.

In the greenhouse the following scheme was carried out. Three boxes of earth had onion smut spores added to the soil in abundance. One of these boxes in addition had sulphur added at the rate of 1 part to 200 of soil. A second received nothing, while the third had corrosive sublimate mixed with the soil, 1 part to 4,000.

In another set of three boxes the soil was free from smut, but the seed rolled in sulphur and smut spores in one case, untreated in the second and smeared with spores and soaked in corrosive sublimate solution, 1 part to 1,000 for one hour in the third.

The onion plants came up well in all six of the boxes and were afterward transplanted to the open ground. As no smut appeared upon any of the onion plants, there are no results with fungicides to be recorded. It is likely that the spores were already dead before they were employed in the experiment.

EXPERIMENTS WITH CORN SMUT.

A series of experiments in every way similar to that above enumerated for onion smut was carried out with corn smut (*Ustilago maydis* D. C.) and with similar negative results. A variety of popcorn, " White Pearl," was used and the soil, or the grain, as the case may be, was inoculated with spores obtained from ears of common field corn in a neighboring stack of stalks. The experiment was carried through in the greenhouse.

Fungicides and Spraying.

Upon the crops previously considered in this report, experiments have been carried out with fungicides. Four substances have been used as a spray, namely, Bordeaux, soda-bordeaux, potash-bordeaux and ammonia-bordeaux, while several other fungicides have been

added to the soil in various strengths, each of which receives mention in the following pages.

Mr. J. A. Kelsey, as field assistant, has had charge of the work of spraying, much of which was done by Mr. Thos. E. Gravatt, a member of the Senior Class, who spent his three months' vacation upon the experiment area.

EXPERIMENTS WITH BORDEAUX MIXTURE.

Bordeaux as recommended in previous reports from this department, is prepared according to the following formula:

Copper sulphate (bluestone)	5 pounds.
Quicklime	5 pounds.
Water	50 gallons.

To dissolve the copper sulphate, it should be put in a bag of some coarse material and suspended so as to dip into the water not more than two or three inches. When so suspended many pounds of the substance will dissolve in a few hours without further trouble, while if a like amount be simply dropped into the water the crystals will go at once to the bottom, and unless stirred long and vigorously, except in boiling water, it will require days for all to completely dissolve. One gallon of water to each pound of the bluestone is sufficient. It will be found most convenient, especially when five pounds or more are to be dissolved, to suspend the bluestone in water over night, as above directed. The process of solution may be greatly hastened by the use of hot water, which is often much more convenient when small quantities of Bordeaux are to be prepared at once, but if several hours are allowed, cold water will answer equally well. Only wooden or copper vessels should be used to contain either the copper sulphate solution or the prepared Bordeaux.

To combine the two constituents, copper sulphate and lime, the diluted lime-wash may be poured into the diluted copper solution, or *vice versa*. Before using, the mixture should be thoroughly stirred. It has been found that the Bordeaux mixture remains in suspension much longer if the two constituents are each diluted to one-half or one-fourth the volume of the prepared Bordeaux when ready for use, instead of mixing the two in a more concentrated form and diluting afterwards. For example, if it is desired to make up 50 gallons of Bordeaux, dilute the copper sulphate solution and the milk of lime

each to 25 gallons; the two, when combined, will be ready for use without further addition of water. Instead of diluting the two constituents to 25 gallons each, it may be found more convenient to dilute each to half that quantity, or 12 5 gallons, and after mixing the two add 25 gallons of water.

Prepared according to the above formula, the mixture contains lime greatly in excess of the amount actually required to neutralize the copper sulphate; but for the use of those unfamiliar with the preparation of fungicides, the Bordeaux so prepared possesses the advantage of being absolutely safe.

The spraying at this Station has thus far been done with a five-gallon knapsack pump, which for small areas will be found most convenient. For treating entire fields or for spraying orchards and vineyards a force-pump, attached to a tank mounted on wheels, will be found necessary. Spraying machinery, to suit most requirements, can now be obtained from a number of reliable firms throughout the country.

In the Bordeaux formula employed during the season of 1895, the percentage of lime was somewhat reduced, as shown below:

Copper sulphate	6 pounds.
Quicklime	4 pounds.
Water	60 gallons.

During the present season the lime was added not much in excess of the amount actually required to produce an alkaline reaction, and was about half the amount called for in the formula just stated. The proportions were as follows:

Copper sulphate	6 pounds.
Quicklime	2 pounds.
Water	60 gallons.

As a fungicide, Bordeaux, prepared according to the last-mentioned formula gave as good results as a like number of sprayings with Bordeaux prepared according to the formula employed in 1895. When sprayed upon the foliage, the Bordeaux prepared according to the new formula is not nearly so conspicuous and therefore less objectionable as a fungicide with which to treat ornamental plants.

All danger on account of there being insufficient lime to neutralize the solution may be avoided by testing with a bit of red litmus paper,

nly a small supply of which will be necessary for a season's sprayings nd can be obtained at any drug store. If the paper when dipped in Bordeaux turns blue, the mixture is alkaline and can be applied to oliage without fear of burning; but should the color of the litmus emain unchanged, more lime should be added until a blue color eplaces the red in the test paper.

Bordeaux with Potatoes.

In 1894 it was attempted to prevent potato scab by soaking the seed to be planted in certain belts in different strengths of Bordeaux, and afterward spraying it in the open row with like strengths of that mixture. No results of practical importance followed. Spraying the vines with Bordeaux during the same season was likewise void of results, since the leaf blights common to the potato were almost wholly absent. The crop was seriously injured by a stem blight, upon the development of which the Bordeaux mixture had no apparent effect.

The following season (1895) the seed planted in the cultural belt (6) of Plot II. of Series II. was sprayed in the open row at the rate of 4,320 gallons per acre. Thirty per cent. of the yield from the belt so treated was free from scab, while none but scabbed tubers were obtained from the remaining belts in the same plot.

The vines were considerably injured by leaf blight (*Macrosporium*) except in Plot I., sprayed with Bordeaux. Here there was comparatively little blight, and the vines continued green for about three weeks after those in the remaining plots were dead.

The present season the cultural belt in Plot II. of Series II. was again treated with Bordeaux, as in 1895. That is, the seed in the open row was sprayed, together with the soil about it, with Bordeaux mixture at the rate of 4,320 gallons per acre. Only negative results followed, since it was found at harvest time that the potatoes from the belt so treated were, without exception, badly scabbed.

The vines of the first belt of each plot in Series II. were sprayed eleven times with Bordeaux. Very little leaf blight of any sort was manifest upon the crop, so that no perceptible difference was observed between sprayed and unsprayed belts. The second plot of Series III., IV. and V. were also devoted to potatoes, and the second belt of each plot was sprayed with Bordeaux, but without results, owing to the almost entire absence of any of the fungous

enemies that so frequently infest the foliage of this crop. The potato vines upon a portion of Series VI. were also sprayed with Bordeaux with like negative results.

Bordeaux with Beans.

In 1894 an attempt was made to prevent the development of the well-known pod spot or anthracnose of the bean (*Colletotrichum leganarium* Pass.) by soaking in Bordeaux seed known to be infested with the germs of the disease. No favorable results from this method of treatment were obtained, and it was therefore abandoned.

The spraying of bean plants in 1894 and 1895 gave much more satisfactory results. The percentage of anthracnose and that of the bacterial blight were much lower in the bordeauxed belts than in the checks.

The merits of Bordeaux as a preventive of bean blights had been sufficiently demonstrated by the experiments of 1894 and 1895, and it was used the present season as a standard with which to compare the two trial fungicides, soda-bordeaux and potash-bordeaux. One belt was devoted to each of the three fungicides in each of the two bean plots.

In the first crop the anthracnose was much more prevalent than the bacterial blight, but as will be seen by referring to the tables of results given elsewhere, both forms of disease were confined almost wholly to the unsprayed belts. So far as indicated by the results of the first crop, there was no practical difference in the fungicidal merits of the three mixtures used.

The plot (I. of Series V.) which has been in beans for three years was again planted to the same variety (Golden Wax) July 17th. The beans upon the new land, Plot IV. of Series III., were followed in August by three varieties of lima beans. The order of spraying was the same for both sorts as in case of the preceding crop. Blight was much more prevalent upon the Golden Wax beans than in the spring, and was almost wholly of the bacterial sort, there being only a small percentage of the anthracnose. The percentage of spotted pods in the sprayed belts, though considerably greater than in the same belts for the first crop, was not sufficient to be of practical importance. On the other hand, the total yield of the check belt was lower than that of the sprayed and the percentage of blight was more than five times as great. As in the first crop, the percentage of infested pods was almost the same in each of the sprayed belts.

No results were obtained from spraying in the plot devoted to lima beans, since the crop remained practically uninfested by fungous enemies.

Bordeaux with Tomatoes.

Extensive use was made of Bordeaux as a leaf fungicide in the experiments with tomatoes in 1894, but practically no results were obtained, owing to the almost entire absence of any of the leaf blights that frequently infest this crop.

The crop of 1895 was somewhat, though not seriously, injured by blight, and the belt sprayed with Bordeaux was noticeably freer from disease than were the checks.

The tomato crop of 1896 was the first to be seriously infested by leaf blight since the experiments with tomatoes began. Blight, due chiefly to the fungus *Septoria lycopersica* Speg.,* was noticeable in early summer, and as a result of its ravages the plants in the unsprayed belts were almost defoliated by the end of August.

Bordeaux was one of three fungicides employed and was applied fourteen times, at intervals of about ten days, to the plants of belt 2. As shown in the table of results, on page 334, the yield in this belt was somewhat greater and the percentage of spotted fruits less than in any corresponding area in the plot. Had a record been made of the weights as well as the number of fruits produced upon the several belts, the difference between the product of the sprayed and unsprayed vines could doubtless be made much more evident, for the fruits produced upon the unsprayed belts were noticeably smaller. On account of their being much more exposed to the sun, the tomatoes borne by the unsprayed vines ripened earlier and more rapidly than did those upon the sprayed vines. As might be expected, such tomatoes were inferior in quality to those ripened under normal conditions.

Bordeaux with Peppers.

An unsuccessful attempt was made in 1895 to prevent the fruit rot of peppers (*Colletotrichum nigrum* E. & Hals.) by the use of Bordeaux. Although the percentage of spotted fruits was not large, the bordeauxed belts were as much infested as the checks, and the plants so treated were somewhat injured.

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*Two other fungous parasites, *Macrosporium solani* E. & M. and *Cladosporium fulvum* Cke, were also present but to a less extent than the *Septoria*.

Bordeaux was again applied to one belt of peppers the present season. As in 1895, the crop was free from leaf blight, but the percentage of fruit rot was considerably greater than in the preceding crop, and was as abundant in the sprayed belts as in the checks. The bordeauxed plants this year were uninjured, which may have been due to the more favorable season, or to the fact that a smaller amount of lime was used in the preparation of the fungicide.

Bordeaux with Egg-plants.

Very favorable results were obtained in 1895 from the use of Bordeaux as a preventive of the egg-plant leaf blight and fruit rot (*Phyllosticta hortorum* Speg.) The yield of marketable fruits produced upon the belts so treated was more than double that from the untreated belts, the difference being due chiefly to the greater prevalence of fruit rot among the unsprayed plants. In all the belts there were a few plants destroyed by an obscure stem disease, and upon this the Bordeaux had no apparent effect.

In 1896, egg-plants were grown upon the ground occupied by that crop in 1895, and one belt was sprayed fourteen times with Bordeaux at intervals of about ten days. Although the Phyllosticta was abundant in the first crop, it was much more so in the second, and seemed to develop almost as rapidly among the sprayed plants as the among the unsprayed. The stem disease observed in the crop of 1895 was much more prevalent the present season, and about one-fifth of the plants were destroyed by it. As in the previous crop, its development was apparently unchecked by the Bordeaux mixture.

It is believed that the fruit rot might have been materially diminished had the Bordeaux been applied at more frequent intervals—as often as once in five days, perhaps, rather than once in ten or twelve.

Bordeaux with Cucumbers.

The two belts of cucumbers sprayed with Bordeaux in 1895 were noticeably freer from the cucumber mildew (*Plasmopara Cubensis* B. & C.) and the anthracnose (*Colletotrichum leganarium* Pass.) than were the surrounding belts. The vines so treated were likewise much less infested by the common cucumber beetle. As a result of the spraying the yield of fruit was largely increased, and, unlike that from the remainder of the belts, was but little infested by fruit rot.

The cucumber fruits in the plot of Series V. were harvested when about half ripe, and were but little decayed. Those in Series IV. were left upon the ground for a time and the sprayings continued. At the end of about four weeks there was found to be a marked difference between the sprayed and unsprayed as to the percentage of fruit rot. Decayed cucumbers were fewer in the bordeauxed belt than in the check by nearly 40 per cent.

Two belts of cucumbers were sprayed this season, but the experiments with this and other fungicides were almost void of results as preventives of leaf fungi on account of the unusual prevalence of the cucumber beetle. Not so many of the seedling cucumber plants were destroyed in the sprayed belts by the insect pest as in the unsprayed, but the plants were sufficiently injured by subsequent attacks to cause them to die prematurely.

As shown elsewhere (page 343), the yield of fruit was noticeably greater in the sprayed belts than in the unsprayed. The difference in yield must, however, be attributed chiefly to there having been a better stand of plants in the sprayed belts. Cucumber blight, chiefly anthracnose, was much more abundant upon this year's crop than upon that of last season, but the vines were destroyed by the beetle before the blight had developed sufficiently to affect the yield.

The cucumber fruits of one plot were left upon the ground to ripen, and were sprayed regularly until harvested, at which time the amount of fruit rot was found to be less in the sprayed belt than in the check by almost 40 per cent.

Bordeaux with Celery.

Celery plants sprayed with Bordeaux, in 1895, gave very decided results in favor of the use of that mixture. The yield, by weight, of the belt so treated was greater than that of the check belts by 55.6 per cent. The difference in yield may be said to have been almost wholly due to the greater prevalence of the celery blight (*Cercospora Apii* Fr.) upon the unsprayed plants.

For the present season, no results followed from the use of Bordeaux, or any of the other fungicides employed in the celery experiments, owing to the fact that the plants, whether sprayed or unsprayed, remained almost wholly free from any form of blight.

Bordeaux with Beets.

One-sixth of the area devoted to beets the present season was sprayed with Bordeaux for the purpose of preventing the common beet leaf blight, *Cercospora beticola* Sacc. It was further desired to compare its fungicidal properties with those of the three other mixtures employed upon the same crop. The plants were sprayed twelve times in all, the first application being made June 6th and the last September 30th.

The blight was manifest in the check belts within one month after the plants appeared, and as the season advanced a large percentage of the older leaves was destroyed. The foliage of the bordeauxed plots was not materially injured, and when harvested showed an increase in weight over the average of the two checks of 77.5 per cent. The root systems of the sprayed plot showed a corresponding increase of 46 5 per cent.

The relative amount of leaf blight noted during the season and the comparative weights of foliage and roots obtained at harvest time would indicate that in this instance Bordeaux as a fungicide is considerably superior to soda-bordeaux. Compared with potash-bordeaux, however, it was found that the per cent. of leaf spot was somewhat greater upon the bordeauxed plot, and after making due allowance for the difference in soil fertility, the yield obtained from the potash plot was somewhat higher.

Bordeaux with Sweet Potatoes.

The mildew (*Cystopus ipomœæ panduratæ* Farl.), commonly found upon sweet potato vines, was noticeable in the belt of sweet potatoes spoken of on page 328, and while not sufficiently abundant to be injurious to the crop, was seen to be much more prevalent upon the unsprayed vines than upon those sprayed with Bordeaux.

Bordeaux with Cosmos.

One-sixth of the cosmos plants were sprayed eight times with Bordeaux. Only negative results followed the treatment, since the stem fungus (*Phlyctæna* sp.) seemed to develop as rapidly upon the sprayed as upon the unsprayed plants.

Bordeaux with Sunflowers.

One-sixth of a row of sunflowers was sprayed seven times the present season with Bordeaux at intervals of about ten days. The sunflower is particularly subject to two forms of blight—the one a true rust (*Puccinia Tanaceti* D. C.), which attacks the foliage chiefly, while the other (*Phlyctæna* sp.) infests the stem. The last-mentioned disease was not conspicuous until after most of the seed was mature, and so affected the yield but little. It seemed, however, to be as prevalent in the sprayed belts as in the checks. The rust was first observed about the middle of August, and spread much less rapidly in the sprayed belts than in the checks. At the end of the season the bordeauxed plants were much less infested by rust than the unsprayed, but rather more than those sprayed with potash-bordeaux and somewhat less than the ones sprayed with soda-bordeaux.

Bordeaux with Hollyhocks.

Very favorable results were obtained, in 1896, from the use of Bordeaux as a preventive of hollyhock leaf blight. The sprayings were eleven in number, at intervals of about ten days. The unsprayed plants were apparently uninfested until September, when one of the common hollyhock leaf blights (*Cercospora Althæina* Sacc.) began to develop, and before the close of the season was quite conspicuous. The bordeauxed plants remained practically uninfested.

Bordeaux with Cercis.

In a row containing twenty young cercis trees, four of the number were sprayed throughout the present season with Bordeaux. Sixteen applications were made in all. The fungous disease (*Cercospora cercidicola* Ell.) so destructive to the foliage of the cercis was not in this instance sufficiently abundant upon any of the young trees to be at all harmful. Late in the season the blight began to be somewhat noticeable upon the foliage of the unsprayed plants, but not elsewhere.

Bordeaux with Pæonies.

The present season twelve pæony plants were sprayed sixteen times with Bordeaux at intervals of about ten days. No results were obtained, since the plants throughout the row, whether sprayed or not, remained uninfested by any of the fungous enemies peculiar to pæonies.

Bordeaux with Gladiolus.

The gladiolus plants grown in 1896 were entirely free from blight, and therefore no results were obtained from the use of Bordeaux or any other fungicide.

EXPERIMENTS WITH SODA-BORDEAUX.

In the spraying experiments of 1896, a second fungicide, which has been termed soda-bordeaux, was used to the same extent as the Bordeaux mixture discussed in the preceding pages. The soda-bordeaux differs from the common Bordeaux in that caustic soda (sodium hydrate) is used instead of lime to neutralize the copper sulphate solution.* The mixture was prepared the present season according to the following formula:

Copper sulphate	5 pounds.
Caustic soda	1.1 pounds.
Water	50 gallons.

Ten pounds of soda will dissolve readily in two gallons of water, and should be kept in closed vessels, other than wood, which may be drawn from as desired. A two-gallon solution of the above will be sufficient alkali with which to prepare 455 gallons of the soda-bordeaux. A somewhat limited use was made of soda and copper sulphate in 1895, and the results obtained were sufficiently favorable to warrant their being given a further trial.

It will be found more convenient to dilute the required portion of the stock soda solution as was recommended in case of the lime used in the preparation of Bordeaux. The amount of soda called for in the above formula is somewhat in excess of the amount actually necessary to neutralize the copper solution. If the specified amount is used, the excess of soda will not injure the foliage to which the soda-bordeaux is applied any more than does an excess of lime in the ordinary Bordeaux. The mixture will be found more satisfactory, however, if only enough soda is added to neutralize the copper. Pour the soda gradually into the copper solution and stir thoroughly. When most of the alkali has been added it is well to test the mixture with red litmus paper, as recommended in the preparation of Bordeaux.

*A similar fungicide was employed last year, under the tentative name of "Hydrate," mentioned upon page 287 of the report for 1895.

As soon as the litmus shows the slightest change in color, from red to blue, the addition of the soda solution should cease.

The one objectionable feature in alkaline soda-bordeaux is, that the precipitate, blue at first, changes in a short time to brown, after which it settles much more quickly than does the neutral mixture. If one is careful to occasionally shake the knapsack pump, or to keep the mixture well stirred, if the receptacle is a barrel or tank, the settlings need not greatly interfere with the fungicide being evenly applied. In a future report or bulletin the full details of compounding this mixture will be given.

Soda-Bordeaux with Potatoes.

The proportion of potatoes sprayed in 1896 with soda-bordeaux was the same as that sprayed with Bordeaux, and a like number of applications were made. The areas sprayed with this mixture consisted of the first belt in each of the four plots of Series II., and the first belt in each of the potato plots in Series III., IV., and V. Each of the belts above designated received eleven applications of the soda-bordeaux at intervals of about ten days. One of the plots in Series VI., devoted to Early Rose potatoes, was sprayed six times with the same fungicide.

The foliage of the unsprayed potatoes was so little injured by blight that no opportunity was afforded for testing the fungicidal properties of soda-bordeaux, or any of the other mixtures employed upon this crop.

Soda-Bordeaux with Beans.

The first belt in the two plots devoted to beans the present season was sprayed with soda-bordeaux. In the first crop, five applications of this fungicide were made to each of these belts. As shown in the table of results on page 331, the pods produced in the first belt of Plot I., Series V., were practically free from blight, while 14 per cent. of those from the check belt were spotted. Between the soda-bordeauxed belt and its check belt in the bean plot of Series IV., there is seen to be essentially the same difference in favor of the sprayed belt. In the first crop the soda-bordeaux seemed to be as efficient a fungicide as either Bordeaux or potash-bordeaux. The bean plot of Series V. was replanted with "Golden Wax" beans, and lima beans followed

the first crop in Series IV. The plants in the first belt in each of the two plots were sprayed seven times with soda-bordeaux. The yield and proportion of spotted pods are given in the table of results on page 332. Compared with the product of the check, that of the belt sprayed with soda-bordeaux produced five pounds more of sound pods and only about one-sixth as many spotted pods. This fungicide again compared favorably with the two employed upon adjoining belts. No results were obtained in the sprayed belt of lima beans, since the plants throughout the plot were almost entirely free from blight.

Soda-Bordeaux with Tomatoes.

Very favorable results were obtained in 1896 from the use of soda-bordeaux as a preventive of tomato blight. The first application was made May 25th, and the sprayings were repeated at intervals of about ten days until early October, when the vines were destroyed by frost. The table of results on page 335 shows a considerable increase in the number of fruits produced in the belt here considered over that produced in the check. The foliage of the belt sprayed with soda-bordeaux, like that of the belt with ordinary Bordeaux, was infested to a much less extent than any of the unsprayed belts, and there was a very marked difference in the size and quality of the fruit, which is not indicated in the table of results. As a fungicide the soda-bordeaux gave in this instance practically as good results as did the standard mixture, Bordeaux.

Soda-Bordeaux with Peppers.

Like Bordeaux, soda-bordeaux had no apparent effect the present season upon the fruit rot of peppers, there being as large a percentage of spotted fruits in the belt sprayed with that mixture as in the unsprayed belts.

Soda-Bordeaux with Egg-plants.

Fourteen applications of soda-bordeaux were made in 1896 to a belt of egg-plants without noticeably lessening the prevalence of egg-plant fruit rot. As stated elsewhere of Bordeaux, that mixture failed likewise, the present season, to check this malady.

Soda-Bordeaux with Cucumbers.

One belt in the cucumber plot of Series V. and one in that of Series IV. were sprayed in 1896 with soda-bordeaux. The cucumber beetle was repelled for the first few weeks by all the fungicides employed, in consequence of which there was a better stand in the sprayed than in the unsprayed belts, and a corresponding increase in the number of fruits produced by the former. The sprayed vines were finally destroyed by the beetles at about the time the leaf blight was beginning to be somewhat conspicuous. The foliage of the checks was seen to be more infested than any of the sprayed belts. Leaf blight was somewhat less conspicuous upon the soda-bordeauxed vines than upon those sprayed with Bordeaux. The fruits in the cucumber plot of Series IV. were left upon the ground, and sprayed for one month after the vines were destroyed. When harvested, the percentage of fruits in the soda-bordeauxed belt was only about two-thirds as great as in the check. It was, however, about five per cent. higher than in the bordeauxed belt.

Soda-Bordeaux with Celery.

In 1895 the "hydrate" was employed as a preventive of celery leaf blight. The percentage of blight was not large in the check belts, but was noticeably greater than in the belt to which the fungicide was applied.

In 1896 there was an almost entire absence of blight from the plot devoted to celery, and no results followed from the application of fungicides.

Soda-Bordeaux with Beets.

The results obtained in 1895 from the use of "hydrate" as a preventive of beet leaf blight were sufficiently favorable to warrant soda being given a further trial.

In 1896, Plot I. of the beet series was sprayed twelve times with soda-bordeaux, and the foliage so treated was much freer from blight than was that of the checks, but was noticeably more infested than were either of the plots sprayed with Bordeaux or potash-bordeaux.

Soda-Bordeaux with Sweet Potatoes.

That portion of the sweet potato belt to which soda-bordeaux was applied was noticeably less infested by the common sweet potato mildew than were the vines in the unsprayed areas.

Soda-Bordeaux with Cosmos.

Eight applications of soda-bordeaux the present season failed, as did a like number of sprayings with Bordeaux, to check the ravages of the cosmos stem blight.

Soda-Bordeaux with Sunflowers.

As a preventive of the sunflower rust, soda-bordeaux was found to be rather less effective than Bordeaux. The soda-bordeauxed plants were, nevertheless, decidedly freer from rust than were those to which nothing was applied, as is shown by the estimate on page 351. The stem blight of the sunflower, which did not seem to be affected by Bordeaux, was likewise unaffected by soda-bordeaux.

Soda-Bordeaux with Hollyhocks.

A portion of a row of hollyhocks was sprayed eleven times with soda-bordeaux during the present season. By the 1st of September the unsprayed plants were conspicuous because of their much-spotted leaves, a condition due to the presence of one of the leaf fungi common to this plant. The hollyhocks sprayed with soda-bordeaux remained practically uninfested, fully as much so as did those to which Bordeaux was applied.

Soda-Bordeaux with Cercis.

The four young trees of cercis sprayed in 1896 with soda-bordeaux showed some good effects for the fungicide.

Soda-Bordeaux with Pæonies and Gladiolus.

No results were obtained from the use of soda-bordeaux in the pæony and gladiolus experiments, since sprayed and unsprayed plants were not attacked by fungous diseases.

EXPERIMENTS WITH POTASH-BORDEAUX.

A third fungicide was used the present season, in which the lime of the common Bordeaux was replaced by caustic potash (potassium hydrate). Copper sulphate, neutralized with this alkali, has been styled potash-bordeaux. It was prepared according to the following formula:

Copper sulphate	5 pounds.
Caustic potash	3 pounds.
Water	50 gallons.

The potash here considered is obtained in bulk, is more or less impure and costs a few cents a pound by the barrel or drum. To bring the hard lumps into solution they may be placed in a kettle of hot water, where they soon become dissolved. Twenty pounds of the caustic potash readily dissolve in five gallons of water and may be kept as a stock solution until desired, in large bottles or a demijohn. A purer form of potash may be obtained in cans, in which case the lid of the can is removed and the can inverted in the kettle, where, with hot water, it is to be brought into solution and stored for use as before stated.

The formula given above will vary somewhat, and when the commercially-pure potash put up in cans is employed it will be well to follow the directions suggested for soda-bordeaux. The red litmus paper will aid in detecting the presence of an excess of the potash. If the test paper turns blue more copper sulphate should be added, but if it remains unchanged potash needs to be added until the test paper shows the slightest tinge of blue, when no more of the alkali should be added.

Like the soda-bordeaux, the potash-bordeaux, if alkaline, changes in color after a time and the precipitate then settles more quickly than before. This change does not take place so soon, however, as in the soda-bordeaux, and if care is exercised not to add an excess of the potash no difficulty need be experienced on this account.

The potash-bordeaux is eventually washed off the foliage and becomes a part of the soil, and, being a desirable plant-food, it thus becomes a valuable fertilizer after having served as one of the constituents of a fungicide.

Potash-Bordeaux with Potatoes.

In 1896 potash-bordeaux was applied, upon the same dates as the other two fungicides employed, to the third belts of all four plots of Series II. and to the third belts of the plots devoted to potatoes in Series III., IV. and V. A portion of the potatoes in Series VI. were sprayed six times with the same mixture. Since the potato vines throughout the experiment area were almost wholly uninfested by leaf blight, no opportunity was afforded for testing the efficiency of the fungicide under consideration.

Potash-Bordeaux with Beans.

Two belts of the first crop of beans were sprayed in 1896 with potash-bordeaux, the number and dates of application of this fungicide being the same as those of Bordeaux and soda-bordeaux. In the potash-bordeauxed belt of Series V. the percentage of spotted pods at harvest time was lower than in either of the other two sprayed belts adjoining; but in the plot of Series IV., the potash-bordeauxed belt, although much less infested than the check, was somewhat more so than the adjoining bordeauxed belt or the soda-bordeauxed belt.

In the second crop of wax beans the potash-bordeauxed belt contained a somewhat smaller proportion of spotted pods than did the bordeauxed belt and only about one-sixth as many as did the check. One belt of lima beans was sprayed with potash-bordeaux, but as already stated, this crop was uninjured by disease, and hence no result followed from the application of fungicides.

Potash-Bordeaux with Tomatoes.

The third belt of tomatoes was sprayed with potash-bordeaux in 1896, with results decidedly favorable to this fungicide. Up to the time when they were destroyed by frost the plants in the belt so treated were not sufficiently infested by tomato leaf blight to interfere with the normal development of the fruits. On the other hand, the plants in the adjoining check were injured to such an extent by disease that a large proportion of the fruits were decidedly inferior, both in size and in quality. The percentage of leaf blight in the potash-bordeauxed belt seemed to be fully as low as in the bordeauxed belt, while the percentage of fruit rot was somewhat higher.

Potash-Bordeaux with Peppers.

About as many spotted fruits developed the present season, in the belt of peppers sprayed with potash-bordeaux, as in the check belt. Like negative results were obtained in this crop from the use of Bordeaux.

Potash-Bordeaux with Egg-plants.

A liberal use of potash-bordeaux (fourteen applications) failed in 1896, as did Bordeaux and soda-bordeaux, to check the development of the fruit rot of egg-plants.

Potash-Bordeaux with Cucumbers.

Until destroyed by insects, the cucumber vines, sprayed with potash-bordeaux, were noticeably less infested by leaf blight than were those in the check belts. In the plot in which the fruits were left upon the ground to ripen, the proportion infested at harvest time by rot was only about one-fourth as great as in the check. As a preventive of cucumber leaf blight and fruit rot, potash-bordeaux gave evidence of being fully as efficient as Bordeaux.

Potash-Bordeaux with Celery.

None of the blights common to celery appeared in the crop upon the experiment area the present season, and therefore no results followed from the application of fungicides.

Potash-Bordeaux with Beets.

The twelve applications of potash-bordeaux to one plot of beets in 1896, resulted even more favorably than did a like number of applications of Bordeaux. The weight of roots produced in the potash-bordeauxed belt was greater than that produced in an adjoining and somewhat more fertile check, by 47.5 per cent. There was an increase in the weight of the foliage of sprayed beets over that of those in the above check, of 78.5 per cent.

Potash-Bordeaux with Sweet Potatoes.

There was noticeably less mildew upon the sweet potato vines sprayed with potash-bordeaux than upon the adjoining unsprayed ones.

Potash-Bordeaux with Cosmos.

The cosmos plants sprayed with potash-bordeaux were to all appearances as thoroughly infested by the stem blight as were the untreated plants.

Potash-Bordeaux with Sunflowers.

A portion of a row of sunflowers was sprayed seven times the present season with potash-bordeaux. From a careful comparison made near the end of the season, it was estimated that there was only about one-eighth as many rust pustules upon the leaves of the sprayed plants as upon those of the checks. The results obtained from the use of potash-bordeaux were slightly better than those which followed from the use of Bordeaux. Like Bordeaux, potash-bordeaux had no appreciable effect upon the sunflower stem blight.

Potash-Bordeaux with Hollyhocks.

As a preventive of hollyhock leaf blight, potash-bordeaux proved as effective as did Bordeaux. The leaves of adjacent unsprayed hollyhocks were considerably blighted.

Potash-Bordeaux with Cercis.

The four cercis trees sprayed with potash-bordeaux remained uninfested by leaf blight throughout the season. The unsprayed were slightly blighted.

Potash-Bordeaux with Pæonies and Gladiolus.

Since the unsprayed pæonies and gladiolus were not attacked by disease the present season, no results were obtained from the use of potash-bordeaux.

EXPERIMENTS WITH AMMONIA-BORDEAUX.

A fourth fungicide, termed ammonia-bordeaux, was given a comparative trial with the three already considered. It was made up in the following proportions:

Copper sulphate	5 pounds.
Ammonia	5 pints.
Water	50 gallons.

The formula for ammonia-bordeaux, as above stated, differs from that for the fungicide known as Eau Celeste, in that the former calls for one-third less ammonia than the latter.*

In the ammonia-bordeaux it was desired to add only sufficient ammonia to produce an alkaline reaction. In preparing a given quantity of ammonia-bordeaux, the alkali should be diluted as recommended in case of lime, soda and potash. For example, if ten gallons of the mixture are to be prepared, the one pint of ammonia should be diluted to five gallons and thoroughly stirred into the copper sulphate solution.

As prepared at first, the mixture contained ammonia in excess of the quantity called for in the above formula, and as a consequence the foliage was greatly injured by burning. Later, the proportion of ammonia used was barely sufficient to produce an alkaline reaction, and the injury from burning was greatly diminished, but the foliage was still noticeably injured. The number of crops treated with ammonia-bordeaux was not so great as in case of the other three fungicides, but a sufficient number were treated, however, to give the mixture a fair trial.

On account of its caustic action upon the foliage, the use of ammonia-bordeaux can scarcely be recommended, although as a fungicide it was perhaps equal to any of the other three employed.

Ammonia-Bordeaux with Beets.

The ammonia-bordeaux was employed the present season as a preventive of beet leaf blight. In all, twelve applications of the mixture were made. The untreated beet plots were badly blighted, but the plot sprayed with the ammonia-bordeaux was comparatively uninfested. The fungicide, as used for the first three or four applications, was found to contain a larger percentage of ammonia than was necessary, the result being that the beet foliage so treated was severely burned. After reducing the proportion of the alkali, the degree of burning was materially lessened, but the objectionable feature was not wholly removed. As a result the yield of roots from that portion of the field so treated was but little more than half as great as in adjacent plots treated with other fungicides. Compared with its check

*Instead of Eau Celeste, a less caustic mixture, known as Modified Eau Celeste, is sometimes used, in which the carbonate of soda in addition to ammonia is employed.

plot there is seen to be a difference in the weight of roots produced of 16.1 per cent. in favor of the check. In weight of foliage, however, that of the sprayed plot was greater by 21.9 per cent.

Ammonia-bordeaux with Potatoes.

The six applications of ammonia-bordeaux to the foliage of one plot of Early Rose potatoes were void of any practical results since little or no blight appeared upon the crop considered. The foliage was badly injured by the fungicide and the weight of tubers produced in the plot so treated was much lower than elsewhere.

Ammonia-bordeaux with Sweet Potatoes.

A portion of a belt of sweet potatoes was sprayed eight times the present season with ammonia-bordeaux. At the time the spraying of this crop was begun the percentage of ammonia used was considerably lower than was that employed in the earlier application elsewhere, so that no such destructive results followed as in case of the round potatoes. The percentage of leaf mildew (*Cystopus Ipomœa-panduranœ* Farl.) was noticeably less upon the vines sprayed with ammonia-bordeaux than upon those of the unsprayed.

Ammonia-bordeaux with Cosmos.

The degree of stem blight upon the two cosmos plants sprayed with ammonia-bordeaux was no less apparently than upon the untreated ones. Other spraying mixtures employed upon adjacent plants of the same sort gave equally unsatisfactory results. The foliage of the cosmos plants treated with ammonia-bordeaux was somewhat injured by burning.

EXPERIMENTS WITH CUPRAM.

The formula recommended for the preparation of cupram is as follows:

Copper carbonate	5 ounces.
Ammonia	3 quarts.
Water	60 gallons.

If enough water is first added to the carbonate to form a thin paste, it will be found to dissolve more readily upon the addition of the ammonia. After dissolving, dilute the solution with water to the desired strength. Cupram is a fungicide that is used by many, in preference to Bordeaux, on account of its being somewhat more easily prepared and less conspicuous upon the foliage. As a preventive of plant diseases, Bordeaux is considered somewhat superior to cupram, and was therefore selected in the experiments of 1895 and 1896 as the standard with which to compare trial fungicides.

TURNIPS AND CABBAGES.—The soil of one belt in the turnip series was treated in 1894 with cupram at the rate of 3,420 gallons per acre, for the purpose of destroying, if possible, the club-root fungus. The turnip plants were materially injured by the application, but the prevalence of the root disease seemed unaffected. The application of cupram in 1894 to the soil of one belt in the cabbage series, at the rate of 3,120 gallons per acre, was followed by like negative results.

POTATOES.—The belt in the cabbage series, treated in 1894 with cupram, at the rate of 3,120 gallons per acre, was planted to potatoes in 1895. Twenty per cent. of the potatoes from this belt were free from scab, whereas all the potatoes in the remaining belts of the same plot were badly scabbed. In the spring of 1896 a second application of cupram, at the rate of 4,320 gallons per acre, was made to the same belt, previous to its being planted to a second crop of potatoes. All the tubers harvested from this belt were scabbed, and to about the same degree as those in the check belt.

BEANS.—In the first and second bean crop of 1894, three belts were sprayed with cupram of double the strength called for in the above formula, and with full and half-strength solutions of the same fungicide. The percentage of blight was much reduced in the belts sprayed with the two stronger solutions, but the plants receiving the quarter-strength application were almost as badly infested as those of the check belts.

TOMATOES.—Six belts in the tomato series were sprayed with cupram in 1894, but as the crop was almost uninfested by leaf blight or fruit decays, no opportunity offered for testing the fungicidal merits of this solution.

Celery.—In 1895 four belt rows were sprayed five times with cupram, at intervals of ten days. The amount of leaf blight at time of harvesting was about 3.5 per cent. less in the sprayed area than in the check, and the product by weight was greater than in the check by seventeen pounds. The amount of blight in the plants sprayed with cupram was about 3 per cent. higher than in those sprayed with Bordeaux.

Beets.—The proposed sprayings of beets with cupram in 1894 were abandoned, owing to the fact that even a half-strength solution of the fungicide severely burned the beet foliage.

Carrots.—Double, half and quarter-strength solutions of cupram were applied to carrots in 1894. The percentage of leaf blight was light throughout the crop, but was noticeably less in the rows sprayed with the double and full-strength solutions. Half-strength was ineffective.

EXPERIMENTS WITH LIME.

Turnips.—Lime was applied in 1894 to three belts of the turnip series, 300, 150, and 75 bushels per acre, respectively. The results of the three years since these applications all show the excellent effect of lime as a remedy for the club-root. The reader may well consult the tables, under the head of "Experiments with Turnips," for a full statement of the effect of lime. After thorough tests for three years, it is evident that lime is not only a good remedy for the club-root, but also its effect lasts in large measure for three years.

Sweet Potatoes.—The Cinnaminson field, where lime in various quantities was applied last year, has been continued in sweet potatoes the present season. The lime has had the effect of reducing the crop, and does not check the development of the soil rot. There is the same noticeable change of form of the roots from the ordinary shape to that of turnips. In short, lime does not agree with sweet potatoes, and cannot be recommended as a remedy for the soil rot.

EXPERIMENTS WITH CORROSIVE SUBLIMATE.

In the field experiments of this Department, corrosive sublimate has been used during the past three seasons, both as a liquid and in its usual powdered form. For soaking potatoes to destroy the scab

fungus, the solution usually recommended is prepared according to the following formula, which is referred to in this report as the full-strength solution:

Corrosive sublimate	1 ounce.
Water	8 gallons.

To dissolve, allow one gallon of hot water for each ounce of the sublimate and dilute to eight gallons. The chemical will dissolve much more readily if an equal weight of common salt is added to the water. The strength of a solution of corrosive sublimate, prepared according to the above formula, is not sufficient to injure the hands, but is a deadly poison if taken internally, and due precautions should accordingly be observed when using it. The solution should be placed in wooden or earthen vessels only.

In greenhouse experiments, the sublimate has either destroyed or materially interferred with the growth of plants when mixed with the soil in proportions smaller than 1 to 4,000 by weight.

TURNIPS.—In 1894 a full-strength solution of corrosive sublimate was applied to belt 6 of the first plot of turnips at the rate of 4,320 gallons per acre. The chemical in this instance appeared to have acted as a club-root fungicide, since the percentage of clubbed turnips produced in the belt so treated was much smaller in 1894 and 1895 than in the check belts of the same plot. In 1896 the proportion of clubbed roots in belt 6 was much increased, being in the first crop somewhat greater than in the check belt.

In 1895 powdered corrosive sublimate mixed with several times its bulk of earth, was evenly applied to two belts of Plot II. of the turnip series. To belt 2 the chemical was added at the rate of 33¾ pounds per acre, and half as much was applied to belt 6. In both belts the percentage of clubbing has continued to increase, and in the belt to which the larger amount was added, the turnips have made but feeble growth for the past two seasons.

The decidedly negative results obtained in the two belts treated with powdered corrosive sublimate, suggests that the low percentage of clubbing in the belt to which liquid corrosive sublimate was applied may have been due to the soil of that belt having been exceptionally free from the club-root fungus at the beginning of the experiment rather than to any fungicidal action of the chemical applied.

POTATOES.—In 1894 three lots of seed potatoes were, previous to being planted in three different belts, soaked in, and sprayed in the open row with full, half and quarter-strength solutions of corrosive sublimate, respectively. The time of soaking varied from one hour for the full-strength solution to two and four hours for the half and quarter-strength solutions. Potatoes grown from the seed treated with the half and quarter-strength solutions were considerably freer from scab than were those grown from untreated seed in adjoining belts. On the contrary, the product of the full-strength belt was practically as badly scabbed as its check. Whether the lower percentage of scab in the half and quarter-strength belts had been due to the treatment received was therefore an open question.

In 1895 potatoes were grown upon another series, which gave evidence later of being thoroughly infested with the scab disease. The seed to be planted in four belts was first soaked for one hour in a solution twice the normal strength, normal, half and quarter strengths respectively. The entire product obtained from the belts planted with seed so treated was badly scabbed.

In 1896 the potatoes planted in one belt of Series II. were first soaked in a double-strength solution of corrosive sublimate, but the yield from this belt was as thoroughly scabbed as that from the check. Like negative results were obtained in Series VI. from soaking seed potatoes for two hours in full-strength corrosive sublimate.

BEETS.—The seed to be planted in one row of beets the present season was first soaked for two hours in a full-strength solution of corrosive sublimate, the purpose of such treatment being to determine whether or not the destruction of any spores that might be adhering to the rough surface of the seeds would make any perceptible difference later on in the degree of leaf blight. No such difference could be detected. The beet seed was apparently uninjured by the treatment.

EXPERIMENTS WITH KAINIT.

POTATOES.—Kainit was applied the present season to two of the belts in the potato series (II.), one at the rate of 600 and to the other 1,200 pounds per acre. Both amounts proved too large, the crop did not come up well and the missing hills were replanted. While the crop was small, some reduction of the scab is to be attributed to the kainit.

SWEET POTATOES.—The hold-over effect of the kainit applied to the sweet potato land in 1895 was such as to make the use of this substance hopeful as a remedy for the soil rot, especially when combined with sulphur.

EXPERIMENTS WITH COPPER SULPHATE.

TURNIPS.—In the spring of 1895, powdered copper sulphate was applied to one belt in the turnip series at the rate of 1,200 pounds per acre, and to another half as much was added. Neither application had any appreciable effect upon the clubbing, and the larger amount interferred seriously with the growth of the turnips.

A weak solution of copper sulphate (1 ounce to 8 gallons), with and without soap, was employed in 1895 as a leaf fungicide. Potatoes, beans, peppers, egg-plants, cucumbers, beets, and carrots were sprayed with the liquid, but as a preventive of blight it proved of no value, and some of the crops were seriously burned.

EXPERIMENTS WITH SULPHUR.

POTATOES.—The belt that was treated with sulphur, 300 pounds per acre, in 1895, was again in potatoes the present season and the crop escaped almost entirely the attack from the scab fungus. It was observed that the side rows of the three in the belt were not quite so free as the middle one. This is a demonstration of the good effect of the sulphur with the second crop, after it has been applied. Sulphur applied the present season, in amounts varying from 120 to 600 pounds per acre, all greatly reduced the amount of the scab. Many farmers who have used sulphur report favorably in all instances.

SWEET POTATOES.—The Cinnaminson field, where sulphur was applied last year in amounts varying from 2,500 to 625 pounds per acre, has been in sweet potatoes again this season, and, without any additional applications of sulphur, it is demonstrated that the soil rot may be greatly checked the second year after the sulphur is used. All three of the new field experiments with sulphur, in amounts ranging from 400 down to 50 pounds, gave similar results, all of them suggesting the profitable use of 300 pounds of sulphur upon land that is much subject to the soil rot.

TURNIPS.—Three of the turnip belts were treated with sulphur at the rate of 300, 600 and 1,200 pounds per acre, respectively. As a preventive of club-root, sulphur for the first year has been of no apparent value, and the largest application interfered with the growth of the turnips.

EXPERIMENTS WITH CARBONATE OF LIME.

TURNIPS.—To one belt of the turnip series, carbonate of lime was added in June at the rate of sixty bushels per acre. No good results were obtained in the next crop. The third crop is still upon the ground at the time of writing, and judging from the appearance of the growing plants this form of lime is wholesome to the crop and may equal the air-slaked stone-lime as a remedy for the club-root when applied in equal amounts.

PEAS.—One-half of a belt of the plot of peas was treated in June with sixty bushels per acre of the carbonate of lime, and gave excellent results. The third crop is still growing, and the results cannot be recorded for the present.

EXPERIMENTS WITH CARBONATE OE SODA.

TURNIPS.—Before planting the second crop of turnips, the present season, carbonate of soda (sal soda) was applied to the soil of one of the belts at the rate of sixty bushels per acre. The substance did not check the club-root and interfered materially with the growth of the turnips, the stand being less than one-half that of the checks.

Irrigation of Garden Crops.

Irrigation was begun upon the experiment area in September of last year, and the reader will find the details of the results then obtained given in the report for 1895, pages 309–317, and in Bulletin No. 115.*

The autumn of 1895 was remarkable for its small amount of rainfall, and the results of irrigation were quite favorable, as shown in the following summary :

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* "Irrigation of Garden Crops," November 30th, 1895, with six engravings.

Summary of Results for 1895.

Irrigation, owing to the lateness in the season when the water was piped to the field, was confined to only a few weeks of autumn. Four crops received the water before it was too late for results to be obtained, namely, a second crop of bush beans, peppers, turnips (second crop) and late celery.

Irrigation is quite favorable to bush beans, there being nearly three times as many pounds of pods upon the belt receiving water as elsewhere in the field, besides the quality was far superior. The estimated cost for the increase of yield is forty-five cents per bushel.

Irrigation prolonged the period of fruitfulness with peppers, and the yield was nearly doubled. The difference in market value was still greater, for the watered plants yielded firm, plump fruits of fine color and quality, while the non-irrigated belts produced opposite results.

With the egg-plants, mulching, which in a sense is a mild form of irrigation, gave very encouraging results. It both greatly increased the yield of fruits and decreased the relative amount of decay.

Irrigation greatly increased the leaf development of turnips, and probably there would have been a corresponding growth of roots were it not for the club-root, which ruined the crop. The good effects of irrigation with turnips may be expected in land free from the club-root.

Irrigation for celery gave satisfactory results, considering the unfavorable soil and situation for growing this crop. In round numbers the crop was increased to two and one-half times that upon belts not receiving the water. In marketable product in pounds the difference was three to one, and in marketable value about eight to one in favor of irrigation.

IRRIGATION FOR 1896.

The present season may be characterized as approaching the normal in rainfall. Thanks are due to Mr. E. W. McGann for the accompanying meteorological tables, showing the rainfall at New Brunswick, N. J., for the past two seasons, March 1st to September 30th:

	1895.	Normal Average For 10 years.		1896.	
March	3.21	4.09	March	5.92	inches.
April	4 59	3.15	April	1.77	"
May	2.72	3.63	May	3.89	"
June	3.03	3.84	June	4.86	"
July	4.24	4.99	July	4.99	"
August	4.40	5.05	August	2.30	"
September	1 34	3.45	September	5.12	"
Totals	23.53	28.20		28.85	"

From this it is seen that the dry spell of the whole growing-season came in April, before many of the experiment crops were started.

During the present season irrigation has been used with a long list of crops, usually one of the six belts (fifth) of each plot being watered.

Irrigation of Turnips.

In the second turnip crop of 1895, the check belts of Plots II. and IV. in Series I. were surface-irrigated, the result being that while the amount of foliage produced by the plants so treated was noticeably greater, the root malformations, due to the club-root fungus, were correspondingly increased. The results of the experiment went to show that water might be applied with advantage to turnips during a dry season, provided the ground was not infested with the club-root fungus, in which case the additional water only increased the virulency of the root malady.

In the first turnip crop of 1896, the fifth belt of each of the four plots was surface-irrigated. Water was applied in the amounts and upon the dates given below:

May	7	50	gallons.	June	3	90	gallons.
"	9	800	"	"	5	945	"
"	10	500	"	"	6	1,400	"
"	11	800	"	"	8	300	"
"	15	500	"	"	9	45	"
"	16	700	"	"	12	275	"
"	18	375	"	"	13	1,620	"
"	19	500	"		Total	10,180	"
"	20	200	"				
"	23	1,080	"				

From the table of results presented on page 300, it will be seen that the amount of turnips by weight and the proportion clubbed were nearly the same for the irrigated as for a majority of the unirrigated belts. As was observed the previous year, the degree of clubbing was greater among the watered turnips than elsewhere.

To the fifth belt of Plot I., Series IV., 740 gallons of water were applied between May 8th and June 9th of the present season, with results essentially the same as were obtained for irrigation of the first crop in the four belts of Series I.

Irrigation of Potatoes.

Belt 5 in each of the four plots of Series II., devoted to experiments with potatoes, was subjected to irrigation. Owing to the fact that this series of plots occupies land with a gentle slope, it was possible to apply water at the upper ends of the rows to be irrigated. There were three rows of potatoes in each of the belts, and the water was applied at first in separate channels near the young plants, and later in the season, after the process of hilling had gone on, the water was added at the bottom of these channels midway between the rows of plants.

The amount of water and the dates of its application are given in the accompanying table:

May 6	90 gallons.	July 16	520 gallons.
" 11	300 "	" 18	180 "
" 12	75 "	August 6	440 "
" 14	200 "	" 7	300 "
" 15	150 "	" 10	720 "
" 16	150 "	" 12	600 "
" 19	675 "	" 13	580 "
" 23	1,075 "	" 14	320 "
June 6	1,350 "	" 21	300 "
" 8	300 "	" 25	450 "
" 9	40 "	" 26	350 "
" 30	450 "	" 29	375 "
July 1	180 "	September 1	900 "
" 2	450 "	" 2	760 "
" 3	280 "	" 3	200 "
" 4	200 "		
" 14	400 "	Total	13,735 "
" 15	875 "		

During the period of irrigation, expressed in the above table, there was no marked difference in the appearance of irrigated plants and those of the belts to which no water was applied, lying on either side.

Three varieties of potatoes were tested in this experiment with irrigation, there being two belts planted with Rural No. 2, and one each with the American Giant and the Early Rose. At harvest time the results were as shown in the tables on pages 315–317.

From that tabulation it may be gathered that the yield in pounds per belt for the irrigated area was as follows:

	Rural No. 2.	Giant.	Rural No. 2.	Early Rose.
Yield..................	76 pounds.	25 pounds.	107 pounds.	84 pounds.
Per cent. of scab....	75	50	85	100

In the corresponding adjoining check belts the results were as given below:

	Rural No. 2.	Giant.	Rural No. 2.	Early Rose.
Yield..................	75 pounds.	34 pounds.	90 pounds.	55 pounds.
Per cent. of scab....	70	75	90	85

From this it is determined that the average yield per belt for the irrigated land is 73 pounds and that of the corresponding belts without irrigation 63.5 pounds, or an increase of nearly 9 per cent., while the average amount of scab upon the irrigated land was 77.5 per cent., and that upon its check belts 80 per cent. It will be seen that there is a slight and unprofitable gain in yield with less scabbiness of crop upon the belts that were irrigated.

Further Experiments in Irrigating Potatoes.

In one of the new series of plots added the present season to the experiment area, irrigation was used with potatoes. In this case the Early Rose was grown throughout the series. Here, again, the rows ran from the upper end of the series to the lower, with a descent advantageous for irrigation.

Water was applied in two different ways, namely, six rows received surface irrigation and a like number had the water added through tiles that were buried in the soil. The tiles were placed midway between two rows to be irrigated, and the depth at which they were

placed ranged from six inches for one row to eight inches for the next and ten inches for the third. The amounts and times of application of the water to the irrigated belts are given in the accompanying table:

	Surface Irrigation.	Sub-Irrigation.
May 6	420 gallons.	420 gallons
" 8	250 "	200 "
" 11	560 "	225 "
" 12	500 "	200 "
" 14	200 "	
" 15	200 "	
" 16		365 "
" 18	125 "	
" 19	3,100 "	180 "
" 20	200 "	180 "
" 24	500 "	120 "
June 3	175 "	
" 5	1,440 "	Total 1,770 "
" 8	720 "	
" 13	720 "	
July 1	720 "	
" 2	300 "	
" 3	370 "	
" 4	180 "	
" 13	200 "	
" 14	400 "	
" 15	450 "	
" 17	100 "	
" 18	120 "	
Total	11,950 "	

During the first few applications to the belt receiving the water upon the surface, channels were quickly made with a garden hoe alongside of the young potato plants. Later on the water flowed down the furrow made by the plow midway between the rows of potatoes.

With the subterranean tiles, some difficulty was experienced in distributing the water evenly over the whole area under irrigation. It was found that the descent was too rapid at the outlet of the tiles at the lower end of the line and the distance, 138 feet, was divided into four sections. The mouth of the lowermost tile of each section was stopped with old cloth, so that the water was applied from the upper end of the whole line to each of these sections successively.

From the table of results of the crop the following figures are drawn: the yield of potatoes for the six rows receiving surface irrigation is 451 pounds, and for the corresponding area with sub-irrigation it is exactly the same amount, 451 pounds. The three rows unirrigated and not otherwise treated gave a yield of 228.5 pounds, which, when multiplied by two for comparison, gives 457 pounds. These figures show that there is no real difference in yield between the irrigated and non-irrigated plants grown in this series under the conditions that prevailed during the past season.

With the exception of a single pound of smooth potatoes produced in one of the surface-irrigated rows, the entire yield of the sub and surface-irrigated rows, and the three check rows here considered, was scabbed. There was some difference as to the degree of scabbiness of the potatoes in different rows, but, as shown below, the average of the estimated scabbiness in the six sub-irrigated and in the six surface-irrigated rows was practically the same, and did not differ essentially from the average for the three check rows.

Average estimated scabbiness of sub-irrigated rows, 88.8 per cent.
Average estimated scabbiness of surface-irrigated rows, 87.2 per cent.
Average estimated scabbiness of check irrigated rows, 89.9 per cent.

The second plots in Series III., IV. and V. were devoted to potatoes and the fifth belt in each plot was irrigated, the water being applied to the surface.

In Plot III. potatoes of the variety Rural No. 2 were grown and water was added to the irrigated belt as indicated in the following table:

May	6	80	gallons.
"	7	200	"
"	8	180	"
"	11	380	"
"	14	180	"
"	16	40	"
"	18	70	"
"	19	150	"
"	23	60	"
June	6	300	"
"	8	75	"
July	1	75	"
July	2	50	gallons.
"	3	180	"
"	4	35	"
"	15	40	"
"	16	20	"
Aug.	5	50	"
"	6	150	"
"	12	100	"
"	13	30	"
"	14	60	"
	Total	2,605	"

As will be seen by referring to the table of results on page 317, the proportion of scabbed tubers in Plot III. was greater in belts 4, 5 and 6 than in the first three belts. Had the percentage of scabbed potatoes been more nearly uniform in all the belts of the plot, the irrigated belt might be compared with that of belt 2 as well as with 4, both of which were planted, as was the irrigated belt, with cuttings from the middle of the potatoes. But since unirrigated belts upon one side of the field have less than 40 per cent. of their product scabbed, while the unirrigated upon the opposite side are practically all scabbed, it seems but fair to limit our comparison of the irrigated belt to the adjoining check belt (4). The yield and condition of the two belts were practically the same; the check produced 6.5 pounds more potatoes, and about five per cent. more of its product was scabbed than was that of the unirrigated belt. It may be said, therefore, that in this instance the addition of water did not appreciably affect either the yield or the percentage of scabbed potatoes.

In Plot IV., devoted to Early Rose potatoes, water was applied upon the dates and in the amounts stated in the table given below:

May 6	80	gallons.	July 2	50	gallons.
" 7	100	"	" 3	180	"
" 11	250	"	" 4	70	"
" 14	120	"	" 14	265	"
" 16	30	"	" 15	100	"
" 19	75	"	" 16	70	"
June 6	300	"	" 18	120	"
" 8	100	"	Total	2,265	"
" 12	80	"			
July 1	275	"			

The table of results on page 315 indicates that practically all the potatoes in all the belts were scabbed, except in the one to which water was added, and in this nearly 30 per cent. were smooth. Compared with belt 2, the yield of the irrigated belt is seen to be greater by 13 pounds and the percentage of scabbed tubers 27 per cent. less. Compared with the adjoining check belt (4), the yield is greater by 13 pounds in the irrigated belt, with 19 per cent. less of scabbed potatoes.

In Plot V., American Giant potatoes were grown, and in the following table are given the dates of application and the quantity of water applied at each time:

May 6	100 gallons.	July 2	50 gallons.
" 7	100 "	" 3	130 "
" 11	200 "	" 4	50 "
" 14	100 "	" 14	110 "
" 16	40 "	" 15	100 "
" 19	40 "	" 16	30 "
" 20	100 "	" 18	50 "
" 23	25 "	August 6	15 "
June 6	300 "	" 7	20 "
" 12	100 "	Total	2,030 "
" 30	150 "		
July 1	220 "		

The results obtained in the irrigated belt of this plot were somewhat different from those obtained in the irrigated belt of Plot IV. The yield in this instance was higher than that of any other belt, except belt 2, which exceeded it by five and one-half pounds. The percentage of scabbed potatoes in the irrigated belt was, however, greater than elsewhere, except in the adjoining "depths" belt (6). The proportion of scabbed tubers in belt 2 was less by 12 per cent., and in belt 4 by 16 per cent. The fact that the percentage of scabbed potatoes in belt 6 is twice as great as in the irrigated belt, suggests that the larger percentage of scab in the latter may have been due to causes other than that of additional water.

Irrigation of Peppers.

Very striking results were obtained in the belt of peppers to which water was added in 1895. The season of fruitage was extended and the total yield was nearly double that of the check belt, as the following table shows:

	Total Number Fruits.	Weight.	Measure.
Check belt	888	80 pounds.	6½ baskets.
Irrigated belt	1,277	147 "	11¼ "

One of the belts in Plot I., Series III., devoted to peppers, was irrigated during the present season with the following amounts of water:

Upon May 23	75	gallons.	Upon August 6	150	gallons.
“ June 3	135	“	“ “ 7	80	“
“ “ 5	90	“	“ “ 12	125	“
“ “ 6	250	“	“ “ 13	200	“
“ “ 13	270	“	“ “ 15	200	“
“ July 1	180	“	“ “ 21	75	“
“ “ 2	50	“	“ “ 25	225	“
“ “ 3	160	“	“ “ 27	250	“
“ “ 4	30	“	“ “ 29	675	“
“ “ 14	227	“	“ September 1	600	“
“ “ 15	50	“	“ “ 3.	175	“
“ “ 16	30	“	“ “ 12	350	“
“ “ 18	35	“			
“ August 5	200	“	Total	4,887	“

With eighty-four plants to a belt, this gave each plant in the experiment fifty-eight gallons of water. The averge yield for the five unirrigated belts is 132 pounds, while that of the one receiving water is 130.3 pounds, or a loss of 1.7 pounds.

The experiment indicates that in a normal season irrigation is not advantageous to peppers.

Irrigation of Tomatoes.

The irrigated belt of tomatoes, Plot III., Series III., received the following amounts of water:

Upon May 16	225	gallons.	Upon August 7	130	gallons.
“ “ 18	200	“	“ “ 8	400	“
“ “ 19	100	“	“ “ 12	200	“
“ “ 20	100	“	“ “ 13	450	“
“ “ 23	50	“	“ “ 15	200	“
“ June 6	300	“	“ “ 21	320	“
“ “ 8	35	“	“ “ 25	300	“
“ July 2	275	“	“ September 1	270	“
“ “ 3	90	“	“ “ 3	400	“
“ “ 15	200	“	“ “ 14	300	“
“ “ 16	130	“	Total	4,715	“
“ “ 18	40	“			

The above amount of water was applied to twenty-four plants, so that the average amount received by each was 196.4 gallons, or in round numbers, 200 gallons.

The table of results (page 335) shows that in the irrigated belt fewer fruits were produced than in the adjoining check belt or in any of the remaining belts. On the other hand, the number of spotted fruits was greater than in any other belt. Another effect of the

additional water, not shown in the above table, was that of the ripe tomatoes produced by the irrigated plants, fully two-thirds were cracked and therefore worthless. The plants in the irrigated belt were infested by leaf blight fully as much as were those of the check, but presented a somewhat better appearance, since they continued to grow and to put forth new leaves when growth had practically ceased elsewhere in the plot.

The results obtained indicate emphatically that irrigation of tomatoes is not advisable during a season in which there is a normal rainfall.

Irrigation of Egg-plants.

The fifth belt of egg-plants was surface-irrigated, each of the 39 plants receiving about 100 gallons of water during the season. Leaf blight and fruit rot were unusually prevalent in all the belts, and most of the fruits were destroyed before they had attained anything like a marketable size. The irrigated plants were not seen to be any more infested than those in adjoining belts. The yield, so far as could be determined under such circumstances, was not much above or below the normal.

Irrigation of Cucumbers.

The check belt of one of the cucumber plots (No. III. of Series V.) received water as stated in the following table:

May 16	75 gallons.	July 3	90 gallons.
" 18	40 "	" 4	60 "
" 19	40 "	" 14	200 "
" 23	20 "	" 15	90 "
June 6	230 "	" 16	50 "
" 12	80 "		
July 1	200 "	Total	1,175 "

A somewhat larger proportion of the young cucumber plants in this belt were destroyed by insects than elsewhere, and the yield was therefore lower than that of the adjoining check or cultural belt. The percentage of leaf blight in the irrigated belt was not noticeably greater than in either of the two unsprayed belts.

In the cucumber plot of Series IV. the check belt was irrigated from May 16th to August 12th, receiving in all about 1,800 gallons of water. Practically the same results were obtained as those just stated regarding the irrigated belt in the cucumber plot of Series V.

Irrigation of Beans.

The fifth belt of each of the two plots devoted to Golden Wax beans was assigned for irrigation, and water applied upon the dates and in the amounts shown in the table below.

Upon the old bean land, Plot I., Series V.:

Upon May 8	25	gallons.		Upon June 13	55	gallons.
" " 11	100	"		" " 30	150	"
" " 14	300	"		" July 1	90	"
" " 15	30	"		" " 2	30	"
" " 16	60	"		" " 3	30	"
" " 18	75	"		" " 4	50	"
" " 19	40	"				
" June 5	150	"		Total	1,230	"
" " 9	45	"				

Upon the new bean land, Plot IV., Series III.:

Upon May 8	25	gallons.		Upon June 6	300	gallons.
" " 11	100	"		" " 8	120	"
" " 12	25	"		" July 1	75	"
" " 14	225	"		" " 2	30	"
" " 15	30	"		" " 4	30	"
" " 16	75	"				
" " 18	40	"		Total	1,375	"
" " 19	300	"				

The increase of the irrigated belt on the old bean land (Plot I., Series IV.) over that of the adjoining check was 8.5 pounds, but it was due to the greater growth of tops, there being five pounds less of pods upon the irrigated than the check belt. As previously noted, the anthracnose was more than twice as abundant upon the irrigated than upon the check belt, but with the bacterial disease the amounts were reversed.

Upon the new land there was a much smaller total yield of beans from the irrigated than the check belt, but as for the old land the weight of tops greatly exceeded that of the pods where water was applied. The irrigated belt here also gave an increased amount, nearly double, of anthracnose over the check belt, and somewhat less of the baterial blight.

For the second crop upon the old bean land (Plot I., Series V.) the water applied, with dates, is as follows:

Upon August 4	150 gallons.	Upon August 26	40 gallons.
" " 5	35 "	" " 29	75 "
" " 6	25 "	" September 1	40 "
" " 7	15 "	" " 2	75 "
" " 12	50 "	" " 3	90 "
" " 13	20 "	" " 14	60 "
" " 15	30 "	Total	740 "
" " 20	20 "		
" " 21	15 "		

In comparison with the check, the pods are found to weigh in the same notch, and the tops showed an increase of one pound. The anthracnose was practically absent from both belts, and while a large amount of bacterial blight was upon the pods of both belts, that of the check exceeding that of the watered belt as 13.7 to 11 pounds.

No profitable results were obtained by the irrigation of beans during the present season, when the natural rainful was near the normal. It is evident that under such circumstances the anthracnose of the crop is considerably increased.

Irrigation of Peas.

The fifth belt in the plot devoted to peas (No. IV. Series V.) received water as indicated below:

May 6	150 gallons.	May 19	50 gallons.
" 7	50 "	June 1	50 "
" 8	30 "	" 3	40 "
" 11	100 "	" 5	45 "
" 12	25 "	" 6	350 "
" 14	75 "	" 8	85 "
" 15	40 "	" 12	70 "
" 16	40 "		
" 18	75 "	Total	1,275 "

As shown in the table of results on page 345, the yield of pods by weight from the irrigated vines was nearly 30 per cent. higher than that produced in any other belt, while the weight of the irrigated vines was more than double that of any corresponding area in the plot.

In the second crop the fifth belt was again irrigated. As stated elsewhere, the vines in all the belts were infested by blight to such an extent that few pods developed. The weight of the irrigated vines was somewhat less than that of the vines in the check belt and were fully as much infested by blight.

The results obtained from the irrigation of peas the present season

show that the application of water to early peas, especially during a dry season, would be profitable, and to late peas as well, provided means can be found for preventing the destructive blights, which are especially prevalent among peas at that time.

Irrigation of Celery.

In 1895 the celery was grown in single rows, and to each alternate row water was applied with very satisfactory results, which were summarized in the report for 1895 as follows: "In round numbers, the crop was increased to two and a half times that upon belts not receiving the water. In marketable product, in pounds, the difference was three to one, and in marketable value about eight to one in favor of irrigation."

During the present season surface and sub-irrigation was begun in the plot devoted to celery, but rains occurred with such frequency as to make the further addition of water superfluous and irrigation of this crop was therefore abandoned.

Irrigation of Beets.

Surface irrigation was tested in the plot devoted to beets. Six rows were liberally supplied with water throughout the season, the first applications being made previous to the appearance of the seedling plants.

The table below shows the amounts of water applied to the beets and the dates of its application:

SURFACE IRRIGATION.

May 7	800 gallons	July 15	1,400 gallons.
" 8	315 "	" 16	1,500 "
" 12	1,500 "	August 6	480 "
" 14	175 "	" 7	540 "
" 15	300 "	" 11	500 "
" 16	350 "	" 12	400 "
" 18	225 "	" 13	700 "
" 19	200 "	" 14	700 "
June 4	135 "	" 21	250 "
" 5	1,260 "	" 25	900 "
" 12	700 "	" 26	1,100 "
" 30	450 "	" 29	375 "
July 1	800 "	September 1	900 "
" 2	550 "	" 2	425 "
" 3	460 "	" 3	775 "
" 4	820 "	" 14	1,050 "
" 13	450 "		
" 14	830 "	Total	22,315 "

It was also intended to sub-irrigate an equal number of rows, and tiles were laid for this purpose, but owing to defective methods they became filled with earth during a heavy rain and were not again opened. The comparatively small amount of water introduced by this method during the second week in May was insufficient to have any appreciable effect upon the yield, and the six rows so treated are therefore included among the unirrigated.

It might be expected that so large an amount of water would either greatly increase or retard the growth of the plants so treated, but at no time during the season were the irrigated beets observed to be noticeably larger or smaller than the unirrigated. In the following table (Figure 44) is presented the yield by weight of roots and tops for each of the 32 rows:

	Number of Row.	Weight of Tops.	Weight of Roots.
	1	51.5 pounds.	222 pounds.
	2	38.5 "	187 "
	3	40 "	185.5 "
	4	35.5 "	185.5 "
	5	48.5 "	245.5 "
	6	47.5 "	254 "
	7	47 "	248.5 "
	8	63 "	336 "
Replanted............	9	32.5 "	38 "
	10	35.5 "	72.5 "
	11	64 "	339 "
	12	56.5 "	286 "
Surface-Irrigated.	13	45.5 "	262 "
	14	55 "	244.5 "
	15	52 "	244 "
	16	47.5 "	229 "
	17	42 "	201 "
	18	37 "	188.5 "
	19	45 "	235.5 "
	20	52 "	248 "
	21	51 "	233 "
Sub-Irrigated (intended)..............	22	57 "	257.5 "
	23	51 "	248.5 "
	24	54 "	261 "
	25	62.5 "	318.5 "
	26	63 "	285.5 "
	27	66 "	302 "
	28	61 "	293.5 "
	29	62.5 "	240.5 "
	30	35.5 "	343.5 "
	31	36 "	249 "
	32	72 "	400.5 "

Fig. 44.

Results of Beet Experiments for each of the 32 Rows.

If, in our comparison, we omit from the above table the last nine or ten rows, the yield of which is seen to be noticeably greater than that of the unirrigated rows elsewhere, it will be found that the average yield of roots and of tops for the six irrigated rows does not differ essentially from that of any six unirrigated rows.*

* Rows 9 and 10 contained two smaller varieties of beets and were planted considerably later than the remainder of the field, and should not, therefore, be considered in the comparison.

It was thought probable that the excessive watering would tend to increase the percentage of leaf blight among the beets so treated, and would, perhaps, favor also the development of beet scab, which had appeared on beet roots previously grown upon the same land.

Leaf blight, however, was no more noticeable in the irrigated belts than elsewhere, and the same may be said concerning the prevalence of beet scab.

The irrigation of beets in 1896 indicates that the addition of water to this crop during a season of average rainfall does not materially increase or diminish the yield and does not tend to increase leaf blight.

EXPERIMENTS WITH MULCHING.

In 1895, a mulch of old hay was applied to a portion of the plants of four different crops, namely, egg-plants, tomatoes, peppers, and cucumbers. The mulched belts, in each instance, were also sprayed with Bordeaux, while an adjoining one was bordeauxed, but not mulched, and served as a check.

Favorable results were obtained from mulching in every instance. In case of egg-plants the total number of sound fruits obtained from the mulched belt exceeded that from the check by 66.5 per cent. The mulched pepper and tomato belts when compared with their respective checks, each showed an increase in the number of sound fruits of about 13 per cent. The total yield of all three of the above belts was somewhat greater than that of their checks. In the mulched cucumber belt there was a falling off in yield, due to a poorer stand of plants, but there was a gain in the keeping quality of the fruits of 4.5 per cent.

In 1896, mulching was employed more extensively than during the previous season, the following crops being so treated: egg-plants, peppers, cucumbers, tomatoes, beans and potatoes. Fresh hay was again employed as a mulch, and, with the exception of potatoes, all the above-mentioned crops received also a mulch of excelsior and salt hay.

These three mulches were employed for the purpose of comparing their merits from a mechanical standpoint, and further to determine whether the plants mulched with one sort of material were noticeably superior or inferior to those mulched with another. Thus it was proposed to determine whether or not a material like fresh hay, contain-

ing nutritive properties that might be imparted to the soil upon which it is placed, would prove to be a fertilizer as well as a mulch, and on that account be more desirable than salt hay containing a considerably lower percentage of food elements, or excelsior, in which such elements are practically wanting. In order to more thoroughly test their efficiency as mulches, each of the three materials employed, instead of being confined to one were added to a portion of two belts. Thus, excelsior was applied to the sixth row of belt 1, sprayed with soda-bordeaux and to the first row of belt 2, sprayed with Bordeaux. Salt hay was used in the belt sprayed with potash-bordeaux (3) and the adjoining check belt (4). One row in the irrigated belt (5) and in the cultural (6), were mulched with fresh hay.

Since the chief value of mulching consists in its enabling the soil to retain its moisture, it is of course much more desirable during a season like that of 1895, when the rainfall was considerably below the normal, than when the soil contains an abundance of moisture throughout the season, as it did in 1896. In case of egg-plants, peppers, cucumbers, tomatoes and potatoes, there was no perceptible difference the present season between the mulched and unmulched rows either in yield or in prevalence of disease. As stated on page 330, the mulched rows in the first crop of beans gave a somewhat larger yield, but there was no practical difference as to the prevalence of leaf blight or pod spot. In the second crop, the yield and percentage of disease were essentially the same in the mulched and unmulched rows.

Excelsior does not become matted down and decomposed as does salt or fresh hay, but might for that reason prove to be less valuable as a mulch during a dry season. Being more expensive than salt or fresh hay, it is most likely to be employed in small gardens only. Fresh hay did not give evidence of having acted as a fertilizer, and since more of it is required to mulch the same area than is required of salt hay, the latter is to be preferred.

The experiments with mulching during the past season, indicate that such treatment is highly beneficial during a dry season, but of practically no value during one in which there is an average and uniform rainfall.

The following table gives the results of mulches with beans:

	Soda-Bordeaux. Unm.	Soda-Bordeaux. Mul.	Bordeaux. Unm.	Bordeaux. Mul.	Potash-Bordeaux. Unm.	Potash-Bordeaux. Mul.	Check. Unm.	Check. Mul.	Irrigation. Unm.	Irrigation. Mul.	Depths. Unm.	Depths. Mul.
Pods	58.5	66.6	72	99	66	108	89	93	96	87	Not comparable.	
Tops	63.5	57	77	81	70	78	84.5	102	103	90		
Total	122.1	123.5	149	180	136	186	173.5	195	199	177		
Gain for mulch.		1.4		31		50		22.5	22 less.			

DEPTH OF SOWING AND PLANTING.

In a portion of the land in beets, beans and peas the seed was sown at definite depths below the normal, with the view of studying the effects upon the crop of such seed treatment, and in particular the susceptibility of the plants to disease.

Beets.—Three rows of beets were sown at depths of two, four and six inches respectively. All seed covered four or six inches failed to germinate, but that at a depth of two inches developed about as readily as did the seed in adjoining rows at a depth of one inch. No difference in disease was observed.

Potatoes.—In each of the three belts devoted to a test of depths, one of the three rows had the seed placed in a trench eight inches below the surface, the next row six inches and the third four inches deep. The total for the three depths of all three varieties is as follows—drawn from a previous table:

	DEPTHS 8 inches.	DEPTHS 6 inches.	DEPTHS 4 inches.
Total	54.5	65.5	50
Scabbed	48.5	55.5	44.5
Clean tubers	6	10	5.5

It is seen that there was the largest yield with the six-inch depth, and also the largest percentage of scab. This agrees with the results obtained with long beets, namely, that the greatest amount of scab germs is in a narrow belt a few inches below the surface. There is a possibility that the process of hilling may be a matter worth considering in connection with the scab.

Beans.—In the first crop of beans the seed was sown in the sixth belt of both bean plots at three different depths, namely, one, four and six inches, respectively. As a result, only about half as many seeds germinated in the six-inch planting, and about two-thirds as

many in the four-inch planting, as in the two rows in which the seed was sown one inch deep.

In the second crop of beans in Plot V. the experiment was repeated, but instead of filling the six and four-inch drills at once, the seed was covered about two inches and earth was gradually added as the plants developed. The stand of plants was almost exactly the same in all the rows, and when harvested the four and six-inch rows gave almost exactly the same weight of tops and sound and spotted pods. Their yield of tops and pods was somewhat less than that of the average of the rows in the remaining belts of the plot. The first four rows in the depths belt cannot be compared with the other two in the same belt, owing to the growth of the latter having been materially interferred with by an adjoining excavation. The experiment goes to show that the sowing of beans at depths greater than the normal is of no advantage, at least in a season of average rainfall.

Peas.—Depths experiments were introduced in the sixth belt in both crops of peas. The plan of the experiment for both crops was as indicated below:

Two rows planted four inches deep and hilled up gradually.
Two rows planted two inches deep and hilled up two inches.
Two rows planted on surface and gradually hilled up to four inches.

The yield by weight of pods and vines was the same for the last two pairs of rows in the above table, and each was greater than that of the first pair by three pounds. In the second crop the yield of the first pair and second pair was about the same and greater than the first. In both crops the product of the depths rows was less than that of the average of the rows in the first five belts.

EXPERIMENTS WITH ORNAMENTAL PLANTS.

A piece of land of about a tenth of an acre lying between the border grass plots upon the west side of the experiment area and Series VI. is assigned to field tests of fungicides upon ornamental plants. In this "field hospital" for flowering herbs and shrubs, a number of kinds of ornamental plants have been treated during the present season. The following notes are upon these several crops, and are given below in the order of their arrangement, row by row, stretching lengthwise of the field, beginning, with pæonies upon the outside border and ending with cosmos next to the field crops:

Fig. 47.
Branch of Cercis badly affected with the Blight.

Fig. 46.
Average Cercis Leaf from Sprayed Plants.

Fig. 45.
Average Cercis Leaf from the nursery rows.

Experiments with Pæonies.

In the outermost row of the ornamental plants, adjoining the grass plots, large pæony plants were set. Two of these plants were sprayed for the pæony blight with Bordeaux, two with soda-bordeaux and two with potash-bordeaux, and the remaining six were left unsprayed. The blight did not make its appearance and therefore no results, comparative or otherwise, can be recorded for the fungicides.

Experiments with Japanese Redbud.

The Japanese redbud (*Cercis Japonica*) is seriously attacked by a leaf spot (*Cercospora cercidicola* E.) Two dozen plants were set in a single row in the area devoted to ornamental plants and sprayed with three fungicides.

At the close of the season there was no marked difference between the sprayed and unsprayed plants, all of them being comparatively healthy.

A visit was made in September to the nursery from which the plants had been obtained, and at that time the Japanese redbud plants by the thousand in the nursery rows were nearly all leafless from a severe attack of the *Cercospora*. The difference between these plants and those taken from the same rows in the spring and introduced into the experiment grounds was most marked. Neither the sprayed nor the unsprayed plants were so badly blighted as those that remained in the nursery rows. This seems to be a striking illustration of the healthfulness that may follow the removal of plants from a locality where its kind has been grown for a term of years in considerable numbers and a disease has developed to a serious extent.

An average leaf from the best plant found at the nursery is shown in Figure 45, while a corresponding average leaf from the best sprayed plant at the experiment grounds is shown in Figure 46. Both of these engravings are from sun-prints, and therefore show the leaves actual size and with the various details.

That the reader may gain a better idea of the extent of the injury of the *Cercospora*, a branch is shown in Figure 47 from a blighted plant from the nursery. This *Cercospora* is not confined to the foliage, but attacks the young twigs and often girdles them and causes

their death. The engraving shows that some of the twigs are dead, while others have attempted to supply their places and are victims to the same enemy.

The writer does not wish to close this item in the report without emphasizing the fact here brought out, namely, that the mere removal of perennial plants from their association with diseased specimens, and placed somewhat isolated upon new land, has a marked tendency to check the fungous enemy. In the present case, the plants were so healthful as to leave but little to be done by the fungicide.

Experiments with Hollyhocks.

One row of hollyhocks (*Althœa rosea* Cav.) was introduced into that portion of the experiment area devoted to ornamental plants. The plants were grown from seed in the greenhouse, and when three months old went into the open ground. The row was divided into six sections, with six plants in each section. Three of these sections were treated with fungicides and three remained as checks. The sprayings were eleven in number, at intervals of about ten days. Very favorable results were obtained, the leading fungus being the leaf blight (*Cercospora Althœina* Sacc.)

The accompanying engravings, Figures 48 and 49, made from sun-prints, show the relative amounts of the fungus upon the plants sprayed with the Bordeaux, soda-bordeaux, potash-bordeaux and the check.

Experiments with Gladiolus.

Two rows adjoining the hollyhocks were set to gladiolus. The bulbs (corms) were a diseased lot that had been sent to the Station for examination. Before being planted they were divided into uniform groups and each lot subjected to a different treatment, as follows:

No. 1. Soaked in kainit solution, 1 to 100, two hours.
" 2. Soaked in hot water, 200° F., quarter of an hour.
" 3. Check. No treatment.
" 4. Soaked in corrosive sublimate, 1 to 1,000, two hours.
" 5. Rolled in suphur.
" 6. No corm treatment. Sprayed with soda-bordeaux.
" 7. No corm treatment. Sprayed with Bordeaux.
" 8. Check.
" 9. No corm treatment, Sprayed with potash-bordeaux.
" 10. No corm treatment. Sprayed with ammonia-bordeaux.

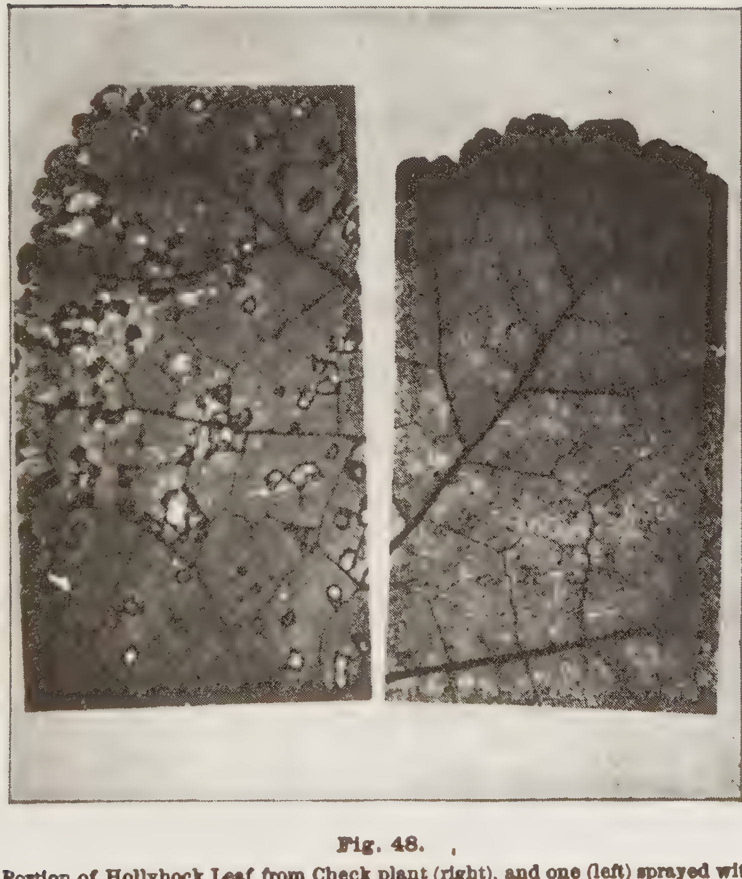

Fig. 48.

Portion of Hollyhock Leaf from Check plant (right), and one (left) sprayed with Soda-Bordeaux.

Fig. 49.

Portion of Hollyhock Leaf (right) from plant sprayed with Bordeaux, and one (left) from plant sprayed with Potash-Bordeaux.

It will be seen that half of the lots were treated before planting, and the other half received sprayings with fungicides, there being a check for each of the two halves.

The rows in the field were divided into ten equal portions, nearly fourteen feet to each section, and twenty corms were set in each, and in the order given in the above table, beginning with the northern end of the rows.

The sprayings were eleven in number, and during the whole growing-season no difference was noted between the sprayed and unsprayed plants. The smooth surface and upright position of the gladiolus leaves prevent, in large measure, the satisfactory adhesion of the fungicides.

In the corm-treated section there are some minor differences in the harvest. The lot of corms from the check section is the smallest, while the ones from where the corrosive sublimate and the sulphur were used are nearly equal and somewhat larger than the others. These corms are to be planted in the same ground next year, and the experiment is therefore not yet at an end.

Experiments with China Asters.

The row next to the sweet peas was set with six varieties of China asters from seed that has been sown in the greenhouse. This experiment was for the purpose of finding some way of getting control of the rust (*Coleosporium Sonchi-arvensis?*) that is often very abundant upon these plants. One variety of the asters was badly attacked and ruined by a stem blight; but the rust was almost entirely absent from all the plants.

Experiments with Sweet Peas.

A somewhat extensive series of tests was made with sweet peas with the hope of finding a remedy for the root and stem trouble so much complained of during the past few years.

A single row in that portion of the experiment area devoted to ornamental plants was sown to sweet peas. The row was divided into sections nine feet long, and received treatment as indicated in the following table:

Section	1.	Seed	placed upon surface,	hilled up 5 inches.
'	2	"	" " "	" " 3 "
"	3.	"	" 2 inches deep,	" " 2 "
"	4.	"	" 5 " "	" " 4 "
"	5.	"	" 3 " "	" " 2 "
"	6.	"	" 1 inch "	" " 1 "
"	7.	"	" 3 inches "	" " 3 "
"	8.	"	" 5 " "	" " 5 "
"	9.	"	soaked in Bordeaux	1 hour, 2 inches deep.
"	10.	"	rolled in sulphur	1 " 2 " "
"	11.	"	soaked in corrosive sublimate	1 " 2 " "

The sowings were upon June 29th, purposely late, in the hope that the root and stem troubles might thereby be more abundant.

The plants in all the sections grew equally well, were very vigorous and showed no signs of the trouble.

Experiments with Cosmos.

One row of that portion of the experiment area devoted to ornamental plants was set to cosmos, and treated with fungicides, especially for the much-dreaded stem blight (*Phlyctœna* sp.) The row was divided into six sections of twenty-three feet each. Two of these were checks and the other four were sprayed eight times, at intervals of ten days, with Bordeaux, soda bordeaux, potash-bordeaux and ammonia-bordeaux, respectively. Posts and wires were employed to keep the plants from breaking down and becoming prostrate upon the ground. The stem blight developed equally upon all the sections, and no favorable results were obtained for the fungicides.

Experiments with Lawn Grasses.

It was desired to have a grass border at each end of the experiment area, and opportunity offered for testing the comparative value of several lawn grasses. The strip of land upon the west side is about twenty-one feet wide at the upper end and narrows down to half that at the lower end. Along the roadside and separating it from the ground devoted to ornamental plants, nine kinds of grasses were tested upon as many small plots, 15½ feet in one direction, and varying from 10 to 20 in the other. The following seeds were sown, beginning with the uppermost plot and nearest to the greenhouse:

			Per cent. of Stand.
Plot	I.	Meadow Fesque (*Festuca pratensis* Huds.) Kansas seed	90
Plot	II.	Five-leafed Fesque (*Festuca tenuifolia* Sibth.) Imported seed	5
Plot	III.	Sheep's Fesque (*Festuca ovina* L.) Imported seed	10
Plot	IV.	Rhode Island Bent (*Agrostis canina* L.) Rhode Island seed	80
Plot	V.	Wood Meadow (*Poa nemoralis* L.) Imported seed	60
Plot	VI.	Kentucky Blue Grass (*Poa pratensis* L.) Kentucky seed	50
Plot	VII.	Rough-stalked Meadow Grass (*Poa trivialis* L.) Imported seed	90
Plot	VIII.	Redtop (*Agrostis alba vulgaris* (With.) Thurb.) New Jersey seed	100
Plot	IX.	Rye Grass (*Lolium perenne* L.) Scotland seed	100

All of these plots received the same treatment, which consisted in running the lawn mower over them to keep down the weeds. At the time of writing, November 17th, there is quite a difference between the several plots. Upon the basis of a stand of plants, in terms of percentages, the nine plots are as given at end of each line. It will be seen that the Rye grass and Redtop are both perfect, followed closely by the Rough-stalked Meadow grass and the Meadow Fesque. The Rhode Island bent is fifth, Wood Meadow sixth, Kentucky Blue grass seventh, while Sheep Fesque and Five-leaved Fesque were very poor.

No mixtures were tested, but the results for the past season with sorts grown alone would indicate that the first five above named would give a satisfactory combination. The glossy richness of the foliage of the Rye grass was an object of remark. This is a coarse grass that would mix well with Redtop and the Meadow Fesque.

The plots at the opposite end of the experiment area did not do so well, as they were in the shade, and were left without care as a severe test of their ability to endure neglect. They were much overgrown by weeds, and more time is needed before judgment can be passed upon this series of plots.

The Herbarium.

During the past year the accessions of the Station Mycological Herbarium have been a few hundred specimens, thus bringing the total up to about 21,000 and representing the following sets of fungi:

Ellis and Everhart's North American Fungi	3,300
Seymour and Earle's Economic Fungi	450
Sydow's Uredineæ	1,050

Sydow's Mycotheca Marchiæ	4,600
Kreiger's Fungi Saxonici Exsiccati	1,050
Lindhart's Hungarian Fungi	400
Briosi and Cavara's Fungi Parassiti	225
Cavara's Fungi Longobardiæ Exsiccati	250
Roumel's Fungi Exsiccati Scandinavici	200
Von Thuemen's Mycotheca Universalis, Vols. 6 to 12, inclusive	700
Arthur and Holway's Uredineæ Exsiccatæ et Icones	50
Allescher and Schinabl's Fungi Bavarici Exsiccatæ. Cents. III. and IV	200
Erikson's Fungi Parasitici Scandinavici. Cents. VII to X	400
Ravinel's Fungi Caroliniani Exsiccatæ. Cent. III	100
Sydow's Phycomycetes. Fasc. I	50
Sydow's Ustilagineæ. Fasc. II	100
Vón Thuemen's Fungi Austrici Exsiccatæ. Cents. VII.-XII	600
Heller's Hawaiian Fungi	30
Pringle's Mexican Fungi	10

The work of carrying on the card index for both the species and the hosts has been continued at intervals during the year, and the host index is complete up to date.

Work with Weeds.

Many weeds for determination have been sent to the Station, and occasionally commercial seeds suspected of containing foul stuff have been submitted for inspection. The work in this direction has suggested the need of some easy and rapid method of studying seeds.

A Weed Seed Holder.

An improvement has been made upon the old method of holding weed seeds for purposes of comparison of suspected commercial seeds. Instead of the dram screw-cap bottles, one hundred in a tray, a case has been constructed consisting of a piece of cherry a foot square and one inch thick, having one hundred pits bored into one side for holding the seeds, as shown in Figure 50. Over the pits holding the seeds, a glass is closely fitted by means of a narrow border that surrounds the holder.

These seeds are arranged in the same order as those of the trays, and a number is stamped below each pit corresponding to a printed list that is pasted upon the bottom of the holder. Light-colored

seeds are glued to a black background placed in the bottom of the pit, while dark seeds are made more conspicuous by being placed upon white paper.

The seed to be examined is scattered upon the glass cover of the holder, and the kinds of foul seeds determined by matching them

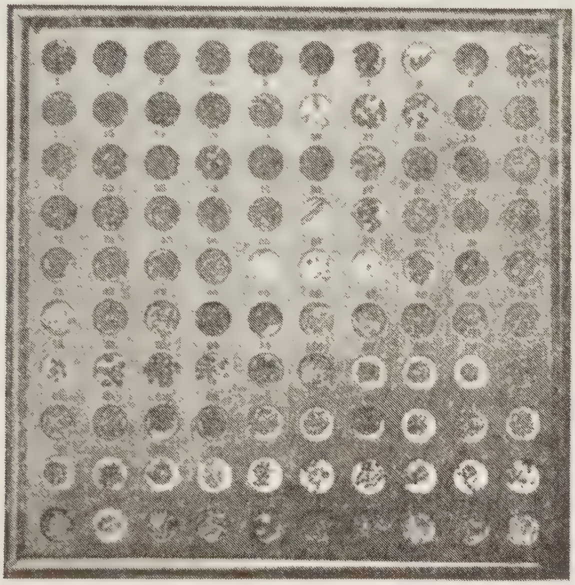

Fig. 50.
A Case for Examining Seeds for Foul Stuff.

with those in the pits directly below the glass. The seeds are removed by tipping the holder and letting them run through a slot left in the border at one corner.

The Russian Thistle.

In the report of last year, pages 348–351, mention was made of the introduction of the Russian thistle (*Salsola Tragus* L.) into New Jersey at the Weehawken station of the West Shore railroad. The discoverer, Prof. Wm. H. Van Sickle, has gone carefully over the region in and around Weehawken the present season, and is able to report that his gathering and burning of the pest last autumn have proved effective, and at the date of his communication, October 20th, 1896, he is able to report that he finds "no trace of *Salsola Tragus* in the Weehawken yards this year."

The notice of the advent of the enemy last year put the crop-growers upon their guard, and some have thought it had been dis-

covered elsewhere in the State, but upon examining samples they were found to be of a closely-related species, the saltwort (*Salsola Kali* L.), that is quite widespread along the seashore from Maine to Florida and is not harmful to cultivated crops. It differs from the Russian thistle in having the leaves and outer branches green and the whole plant less bushy and more fleshy than its pestiferous relative. Engravings of the intruder were given in the report for last year.

DODDER UPON GARDEN VEGETABLES.

During the present season samples of two kinds of truck crops have been sent to the Station that were attacked by dodder. The first lot was that of seedling egg-plants from a hot-bed, the young plants being overrun by the orange-colored threads of the parasite. A second lot was of onions in the open field upon which the dodder had made itself at home. While it is not uncommon to find wild plants, particularly in low ground, covered with the dodder, it is unusual to find it within the cultivated field, and still less so in the hot-bed.

As seen upon the wild herbs and shrubs, it is frequently so rampant as to give the prevailing color of the wire-like threads to the verdure of the attacked area. The reader can get an idea of the appearance of the dodder upon onions from Figure 51,* which is made from a sun-print, and shows the tangled mass of threads as attached to some of the onion leaves. This weed produces numerous flowers, some of which may be seen in the engraving, ripens abundant seeds, which germinate in the soil, and the slender plants afterwards attach themselves to the onion or other host by means of small roots, and through them obtain the nourishment needed for further growth.

There are several species of dodder, one of which (*Cuscuta Epilinum* Weihe) grows upon the flax and often does much damage to this crop. Occasionally complaints are made of a dodder (*Cuscuta Epithymum* Murr.) upon the clovers.

Along with the specimens of dodder upon onions came the statement that "it is increasing every year," which only suggests that truckers should be watchful for these intruders, and realizing that they are flower and seed-bearing plants, destroy them at first sight. Use clean seed and let no dodder go to seed.

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* Published in "Garden and Forest" for September 9th, 1896.

Fig. 51.
Dodder upon Onion Leaves

EXPERIMENTS WITH WATER-LILY BLIGHT.

During the past season there have been complaints made of a serious blight of the water lilies in the artificial tanks and ponds of the growers of aquatics. The appearance of a diseased leaf of a

Fig. 52.
A Blighted Nymphæa Leaf.

nymphæa is shown in Figure 52,* made from a sun-print, and therefore giving all the details in natural size.

The disease is caused by a species of Cercospora, and therefore a member of a large genus, noted for producing small dead areas in the foliage, from which fact the term "leaf spot" is given to

*Under the title of "Leaf Spot of Water Lilies," a short article was published in the "American Florist," for September 5th, from which the above cut has been kindly loaned by the publishers.

many species of the genus. For example, the *Cerpospora beticola* Sacc., causing the familiar spotting of the foliage of the beet, is a near relative of this trouble of the water lilies.

The affected portions of the nymphæa leaf at first lose their normal green color, changing to a yellow and finally a dark brown, after which the dead tissue may break away, leaving small holes in the leaf. Spores of the fungus are borne upon the surface of the spots, and are doubtless easily disseminated by the water and quickly germinate upon the surface of healthy foliage, and thus spread the disease.

Unusual conditions for the propagation and spread of the trouble, obtain with such water plants, and at the same time the ordinary methods for checking it do not seem promising. As subterranean fungi need to be met in the soil, so here it seemed best to add to the water some fungicide, with the hope of checking the disease in the plants it surrounds.

Two lines of experimentation suggested themselves, namely, the use of the ordinary fungicides that have proved effective upon terrestrial plants; and secondly, the adding of fungicides that are but slightly soluble and will float in the water, thereby keeping the foliage of the plants in contact with the remedy. Two of the standard liquid fungicides were employed, and sulphur and a half-and-half mixture of sulphur and oxide of copper were used as floating powders.

Failing to get a preparation of the oxide of copper of sufficient fineness to float, it was thoroughly ground in a mortar with its own weight of sulphur (much more in bulk), when it was easily borne upon the surface of the water.

Tubs (half barrels) were selected, six in each set, as follows:

Bordeaux.	Check.	Sulphur.
Oxide of copper with sulphur.	Check.	Cupram.

These were in duplicate, and later on the substances were introduced into the vats under glass and the pools in the aquatic gardens.

The Bordeaux was satisfactory as a fungicide, but objected to by the gardener on account of the incrustation of lime upon the foliage,

which was much worse than with ordinary land plants when sprayed with the same mixture.

The cupram was preferred to Bordeaux, but needs to be used in weak solution.

The use of the sulphur was not continued, because of the unattractive appearance it gave to the water and foliage of the plants, coating all with its yellow scum.

In the language of the gardener in charge, "the oxide is good," and then he adds in a recent letter, "especially for dusting plants that are liable to 'damp off.'" This mixture of oxide and sulphur has a grayish color and is not conspicuous, and therefore not objectionable, like sulphur, when added to tanks of water plants.

This single series of experiments indicates that the Bordeaux is the most satisfactory of the four substances employed, and when its objectionable feature is removed, namely, the lime, the case of diseased water lilies will be fairly met with a fungicide. There is no reason to doubt that the potash-bordeaux will prove effective and satisfactory, and it is the intention to make a thorough trial of it the next year.

A secondary advantage gained by these fungicides was the destruction of the green filaments, algæ (confervæ), that often prove a menace to the satisfactory growing of water plants. The Bordeaux, for example, in a few days after its first application, began to kill the fine green growth, and in a few weeks the pools were free from it, much to the delight of the gardener.

DISEASES OF THE ASPARAGUS.

Up to the present year there have been but few complaints of fungous troubles with the asparagus. Early in September the growers of this crop became much exercised over a premature maturing of their asparagus fields and sought the Experiment Station for advice. The trouble was a rust that had been so general and complete in its attack as to warrant the alarm. Within a week after, an examination was made of fully two hundred acres of asparagus plants. A circular essentially as given below was issued to the press of the State and other newspapers that circulate in New Jersey:

"AN OUTBREAK OF THE ASPARAGUS RUST.

"The Experiment Station has had its attention called to an unusual development of rust upon the asparagus plant, and as this is new and somewhat alarming to the truck-growers of the State, the following items are published for their especial benefit:

"*General Appearance of the Field.*—When an asparagus field is badly infested with the rust, the general appearance is that of an unseasonable maturing of the plants. Instead of the usual healthy green color, the field has a brownish hue, as if insects had sapped the plants or frost had destroyed their vitality.

"*Close View of the Plants.*—Rusted asparagus plants, when viewed closely, are found to have the skin of the stems, both large and small, lifted as if blistered, and in the ruptures of the epidermis dark-brown spots are readily seen. These brown dots or lines are of various sizes and shapes, and remind the close observer of similar spots in the broken skin of stems of grains and grasses and of the leaves of corn, also due to rusts, but not the same kind as that of the asparagus.

"*Nature of the Rust.*—The asparagus rust is due to a fungus (*Puccinia asparagi* D. C.), that is, a minute plant consisting of microscopic threads which grow through the substance of the asparagus plant, taking up the nourishment that is needed, and finally breaks through the surface to bear the innumerable brown spores that give the dark color to the spots on the asparagus skins. This is the last stage in the development of the rust fungus, and as such remains over the winter. When the warm, moist weather of spring and summer comes, the spores above mentioned germinate, and a new lot of asparagus plants may become infested.

"*Treatment of Infested Fields.*—There are two general methods of checking the rust, namely, by destroying the spores and by preventing their growing upon and getting a foothold in the substance of healthy asparagus plants. The rust fungi are among the most difficult to check—by protecting the plants they feed upon—by means of fungicides, Bordeaux mixtures, etc., sprayed upon them during the growing-season. While something may be hoped for with the spraying pump in July and August, the chief method of eradication lies in the destruction of the spores this fall. This can be done in a very simple and effective manner by carefully gathering all the parts of the asparagus plants that are above ground and burning them. It would be a waste of time to stack the tops and leave them to natural decay, and to place them in manure heaps would be still worse. The only safe thing to do when a serious enemy like this is in the asparagus field is to burn the plants even to the last scrap that can be gathered up. Let this be done at once, for any delay means the breaking up of the brittle, rusty plants and a generous sowing of the spores upon the ground. If the fire could go over the whole field and burn all the small as well as the large pieces, that would be the best of all.

"This autumn burning should be done by every asparagus grower, even if the rust is not yet seen by him. This enemy may become very serious if thorough measures are not taken at once and by all who are engaged in asparagus culture.

"To those who may wish to add to the burning process the spraying of the summer-growing plants—not the spring shoots for market—the Station will have something to recommend later on, but the only thing to do now is to burn the 'bushes.' Instead of 'Arbor Day,' let it be a *smoke day* for the whole State, or wherever there is an asparagus patch.

"BYRON D. HALSTED, *Botanist.*"

"New Brunswick, New Jersey, September 18th, 1896."

Since the issuance of the circular, correspondence has been held with a large number of the botanists and horticulturists in Experiment Stations and elsewhere in the United States, with the result that

Fig. 54.
Portion of Rusted Asparagus Stems. Natural size.

Fig. 53.
Three Asparagus Plants with their Tops Killed by the Rust.

thus far the rust has been reported from New England generally, Long Island and Delaware. A personal examination has been made in our State, and the rust is abundant in all localities that have been visited. No one from the Middle, Prairie or Western Coast States reports the presence of the trouble, and from this it would appear that, at present, the rust of the asparagus is confined to the Atlantic Coast States north of Virginia.

The large growers in South Carolina became much interested in the outbreak, and asked for specimens of the rust, which were sent them, with the precaution that they were all thoroughly poisoned by soaking the blistered stems in a full strength of corrosive sublimate. Specimens afterwards received from the South all showed no signs of the rust. It is interesting to note that the same growers, although assured that they did not probably have the rust, at once concluded to burn their brush, as recommended in the above circular, and thus run as small a risk as possible of having their fields injured by the new enemy that has come so suddenly upon the Northern asparagus fields.

In looking up the history of this *Puccinia asparagi* D. C., only one publication of its having been found in the United States is thus far discovered, namely, in February, 1880, in the "Catalogue of the Pacific Coast Fungi," by Drs. Harkness and Moore. In a recent letter received from Dr. Harkness, he kindly informs me that the rust was found near Sacramento, and regrets that no specimens were preserved. This was over a quarter of a century ago, and it is strange that it has not been collected since that date. It seems to be the fact that the cryptogamic herbaria of the country were without a specimen of the asparagus rust until the present outbreak.

The writer has never met with any species of rust that was so overwhelming in its attack. Fields, for example, of a dozen acres would not have a plant and scarcely a square inch of surface, free from the pustules. It attacks all ages of plants, but the older beds turned brown first, and the last to lose their usual green color were the seedlings. Figure 53 will give the reader an idea of a fair sample of rusted plants. The brush is reduced to the main stems, the finer portions having become thoroughly affected and fallen away. Portions of stems of older plants are shown in Figure 54, where the rifts in the skin may be seen and the spore masses appear as dark blotches.

All the varieties of asparagus seem to be equally susceptible to the

rust, with the exception of the "Palmetto." An examination of several fields of this variety, sometimes growing alongside of other sorts, leads to the opinion that upon a basis of one hundred the "Palmetto" would give a percentage of sixty for rustiness.

When once seen the rust is not easily mistaken for any other disease. There are, however, two fungous troubles of the asparagus that have been misleading. One of these causes brown spots that are nearly circular upon the stems, suggesting, along with the yellow of the surrounding surface, the coat of the leopard. The second is an anthracnose (*Colletotrichum* sp.) and produces multitudes of minute dark specks upon the stems. The appearance of this latter and by no means insignificant pest is shown in Figure 55. It develops later in the season than the rust, and is much finer in its growth in every way.

NASTURTIUM BLIGHT.

From several quarters complaints have come of a blight of the nasturtium. While the plants are quite small, and before the foliage is half the normal size, the leaves will show discolored spots which at first are "watery" in appearance, but soon become blotched with brown. These patches appear without any order and are of all sizes and shapes.

Figure 56, made from a sun-print of two leaves, indicates fairly well the general appearance of this nasturtium blight. This is quite similar to the bacterial blight of beans, and a microscopic examination of the germs suggests that the organism may be the same. One of the worst cases of this blight of the nasturtium was upon plants that were growing within a few feet of a field of beans badly affected with the bacterial blight.

No attempts have been made to check this blight, but from its nature it is quite probably amenable to treatment. Experiments with beans during the past season show good results with the bacterial disease of beans, and therefore it may be presumed that the ordinary fungicides will prove effective with this enemy of the nasturtium.

AN AMPELOPSIS BLIGHT.

The very popular ivy, *Ampelopsis Veitchii*, is a victim to a serious leaf blight, the appearance of which is shown in Figure 57.*

* From the "American Florist" for August 1st, 1896.

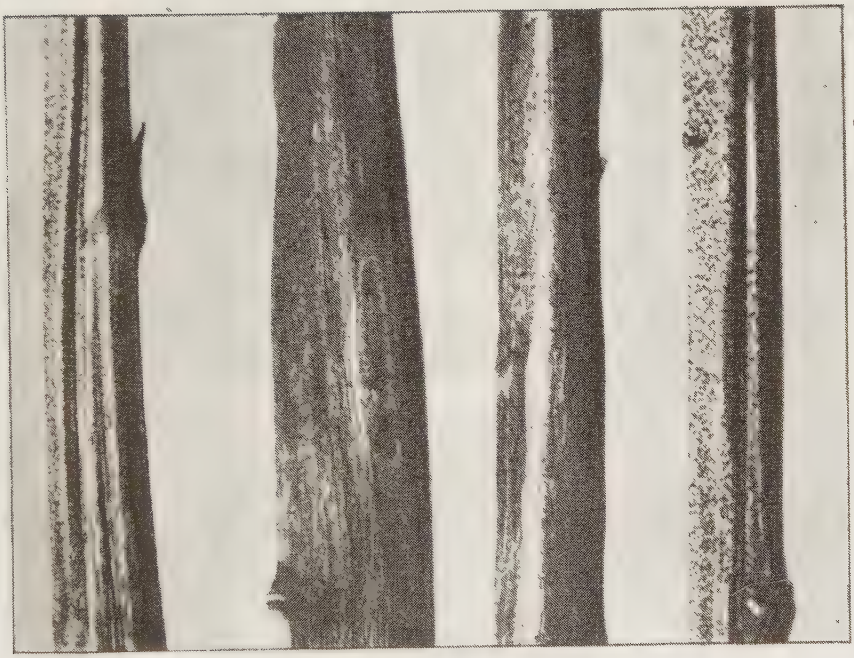


Fig. 55.
The Asparagus Anthracnose.

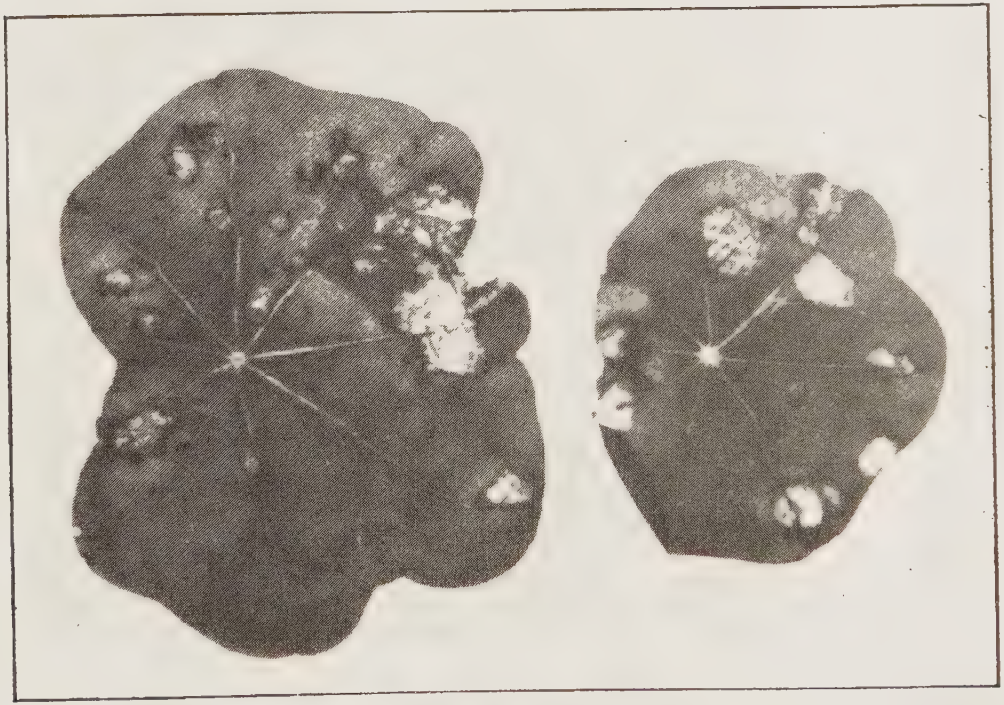


Fig. 56.
Nasturtium Bacterial Blight.

The fungus (*Phyllosticta ampelopsidis* E. & M.) is one of a large genus, many members of which are called "leaf spots," while others take the more general name of "blight."

The fungus makes its entrance into the leaf from the surface, and by spreading, causes a small spot at first of pale green, but later on it enlarges and becomes brown. The spores are produced in small

Fig. 57.

The Ampelopsis Blight.

dark pimples that may be found scattered over the surface of the dead portions of the leaf. From these pimples the spores ooze out and are scattered to other leaves, and thus the blight spreads with considerable rapidity.

It is not difficult to conceive of this blight increasing to an alarming extent, in which case one of the most useful and beautiful of our ornamental plants would require painstaking treatment. There is no

reason, from the nature of the fungus, why this enemy might not be controlled by the proper use of fungicides. The spraying should be done in the same way as for grapevines, which are closely related to the Boston or Japanese ivy and have similar pests to the one here considered.

ANTHRACNOSE OF MAGNOLIA.

The ordinary native *Magnolia glauca* L. is sometimes affected with an anthracnose (*Colletotrichum* sp.) that ruins the foliage and also kills the smaller branches. The general appearance of the anthracnose upon the leaves is shown in Figure 58, where a single leaf is shown half its natural size, with several patches entirely destroyed by the parasitic fungus.

Fig. 58.
Anthracnose of Magnolia.

THE CHESTNUT BLIGHT.

Several complaints have been made to the Station of a blight upon the chestnuts, and particularly those varieties that have been developed in the nursery. A visit was made to some of the localities where chestnuts are grown as a crop, and also to nurseries of young trees. The blight is certainly very striking, as the trees turn to a decidedly brown color, due to the foliage becoming spotted. The appearance of the blighted foliage is shown in Figure 59, made from a sun-print of two diseased leaves. The fungus *Marsonia ochroleuca* B. & C. causes a remarkable spotting of the foliage, and greatly interferes with the work of the leaves. While no experiments have been carried out, there is no reason why this leaf parasite may not be controlled by the use of fungicides, applied in the same way as for orchards.

Fig. 59.
Chestnut Leaves badly Blighted.

Fig. 60.
The Leaf Blight of the Linden.

A BLIGHT OF THE LINDEN.

A leaf-spotting of the linden or basswood has been met with this year that is quite destructive to the foliage. Figure 60 shows a leaf that is badly spotted. This is due to the *Cercospora microsora* Sacc., and from the nature of the parasite it should yield to spraying with fungicides.

EXPERIMENTS WITH PEACH ROOT GALLS.

There have been many complaints of the galls upon the roots of peach trees in the State, and some work has been done upon the subject during the past season. In the last report (1895), pages 359, 360, a brief mention was made of the trouble, and an engraving published showing two specimens of the peach root gall.

Peach pits, originally Southern growth, were obtained from a nurseryman in the State, and the seeds, then beginning to germinate, were planted in the greenhouse upon the 15th of February. In one set of six large pots sand was used, and in a second parallel set common greenhouse earth was employed. Into two pots of each set raspberry galls were added after having been cut up into small pieces; two received minced peach galls and one received nothing. One of the two pots receiving the raspberry galls and the peach galls respectively had sulphur added at the rate of one pound to four hundred of soil.

The scheme stood as given below:

Sand............	Raspberry galls.	Peach galls.	Check.	Raspberry galls + sulphur.	Peach galls + sulphur.
Soil............	Raspberry galls.	Peach galls.	Check.	Raspberry galls + sulphur.	Peach galls + sulphur.

The seedlings were thinned out from time to time and the whole removed from the pots upon September 17th, after a period of seven months.

It was found that the pots, both sand and soil, in which the inoculation had been with minced peach knots, were much more diseased than elsewhere. There were some galls upon all the plants, but the least where no peach virus had been used. There was no difference between the check pots and the ones receiving the minced raspberry

galls. The sulphur showed unmistakable power for retarding the development of the galls. The soil pots showed a much larger development of the galls than those containing sand.

A considerable space in a bench was devoted to a duplicate of the above tests. In this instance the seedlings were grown in rows, and the minced raspberry and peach galls added to the soil in the rows before the seeds were dropped. In like manner the sulphur was added in the open row. Two sets of this experiment were made, separated by three weeks in time, but all harvested upon the same day (September 7th) as the pots above mentioned.

The results in the soil upon the bench were in all respects parallel with those in the pots, and point to the conclusion that the peach root gall is decidedly contagious, and with the seedlings surrounded with minced peach galls the affection is almost certain to appear, and in a violent form. Upon the other hand, the experiments do not indicate that the raspberry root galls (Figure 61), when treated in the same manner as the minced peach galls, have any power to induce the formation of knots upon the peach. All of the experiments show that sulphur may be looked to as a remedy for the trouble. Figure 62 shows three peach roots grown in pots, while Figure 63 gives the appearance of three others grown in soil in greenhouse beds. These are average specimens, and it is seen that they show results as stated in the above tentative conclusion.

A nurseryman was interested in the subject under investigation and kindly followed out a plan that was submitted for trial. A portion of his peach pits were treated to sulphur—one part to 250 of the soil, and another with one part of lime to 500 of the soil. A belt of several rows in the nursery was planted with the sulphured seedlings, and another to those receiving lime. This field was visited by the writer twice during the growing-season, and at both times the rows receiving the sulphur were easily distinguished by their larger size and greater vigor. No galls were found upon any roots except in the check rows. At the close of the second season these plants will be thoroughly examined and results may be then expected. So far as the test has gone, the owner expresses satisfaction with the treatment of peach seedlings with sulphur as a remedy for the peach root galls.

Fig. 61.
Root Galls of the Cultivated Raspberry.

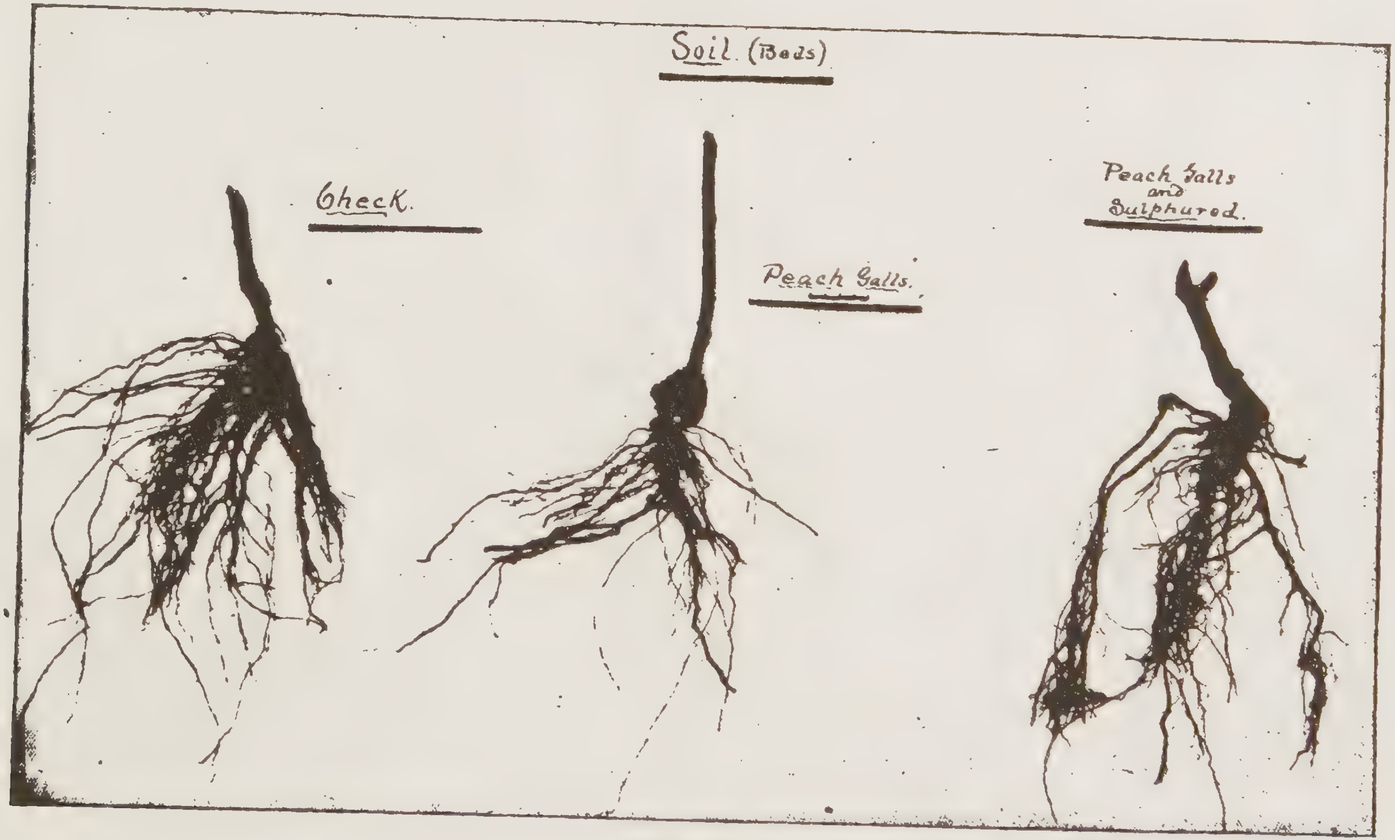
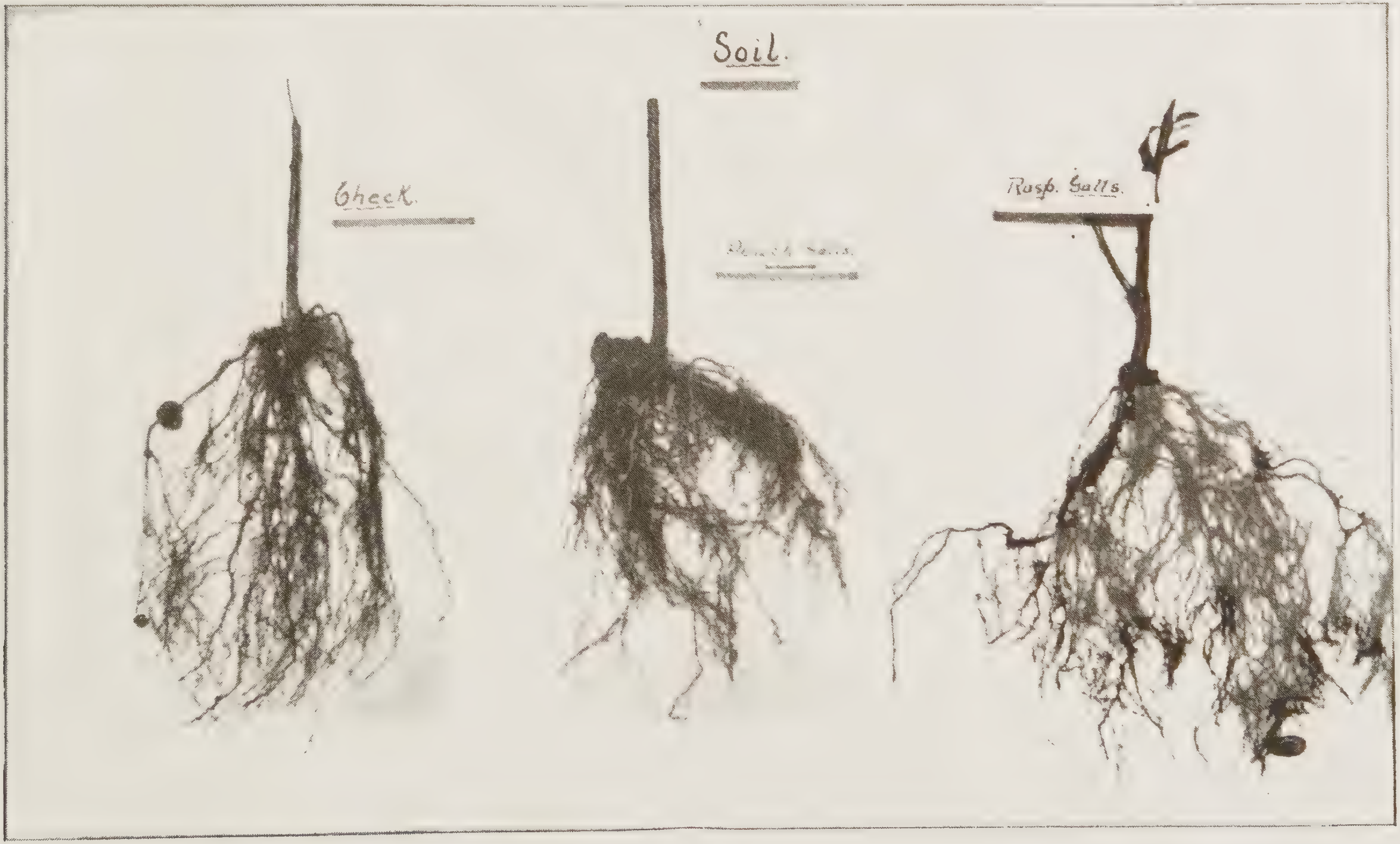


Fig. 62.

Seedling Peach Tree Roots, grown in the greenhouse, with minced Peach Galls, with and without Sulphur as a Check.


Soil.
Check.
Rasp. Galls.

Siftings from Other Sources.

During the past year some notes have been made upon the bulletins of other Experiment Stations and published in "Science" from time to time. Some selections are here made from such notes with the thought that they may be of value to the crop-growers of New Jersey.

SOIL IRRIGATION.

A good deal is being done in the Experiment Stations in the application of water to soils for purposes of crop-growing.

From the last issue of the "Experiment Station Record" (Vol. 7, No. 6), under the head of agricultural engineering, particular mention is made of experiments in irrigation at the Utah Station. Under farm irrigation it is gathered that two feet of water is required for best results with grains upon clay soil, while a sandy soil needs three and a half feet. For wheat, clover and timothy the intervals between irrigation should be about twelve days. With spring wheat there was a decrease of yield when there were more than three waterings. Better results are obtained by day than by night irrigation. Fall watering favored timothy, but not winter wheat. The flooding system is superior to the method by furrows, and the acre-foot unit is recommended by Professor Mills for general adoption.

Under orchard and vineyard irrigation, Professor Richman holds to the opinion that the best plan is to apply the water but a few times, but supplying enough to reach the deeper roots of the trees. Young trees require more frequent watering than old ones, and the opinion is erroneous that water injures the trunks of trees even when confined around the base by heaped-up earth.

Among other bulletins cited is one (No. 25) from the Nevada Station, largely a compilation from publications of the Colorado and Wyoming Stations, etc., and deals with water-storage measurements, pumping, etc. Another is No. 6 of the Montana Station, upon measurements of water, giving value of water, water duties and tables for discharge over weirs. Several other items are given upon this general subject from Kansas and Washington.

There is a manifest growing interest in agricultural engineering, as it relates to the distribution of water over the soil.

While irrigation has been and will continue to be a leading feature

of agriculture in the arid regions of the West, there is little doubt that it will also increase in importance in the East. Field irrigation may not become a common practice along the Atlantic coast, but it seems likely that methods will be provided for supplying water to truck and berry fields when there is a shortage due to drought.

SOIL TREATMENT OF ORCHARDS FOR DROUGHT.

In many parts of our country crop-growing is very uncertain, due to a lack of sufficient rainfall. This fact has led the Nebraska Experiment Station to make a study of methods of mitigating the ill effects of dry weather. Professor Card, in "Some Obstacles to Successful Fruit-Growing," Bulletin 39, Nebraska Experimentation Station, reports results upon an old orchard, a third of which was mowed, a third pastured and the remaining third cultivated every two weeks. The trees in cultivated ground suffered much less from the drought and hot winds than those in sod, the foliage being more vigorous and without the wilting during the hot windy days common to the trees in the sod ground.

The fruit was larger and better upon the cultivated trees than elsewhere. An examination of the soil showed that for every 100 barrels of water in the first twenty inches of sod ground there were 140 barrels in the cultivated ground. The soil in all regions when drought is experienced needs a covering of mulch. It is not practicable to add a mulch of straw or other material, but the upper few inches of the soil when kept light and mellow serves as a mulch for all below. Therefore a key to the solution of the problem is to plow deep; even subsoiling will pay for some crops, and then mulch by means of a mellow layer upon the top produced by frequent cultivation.

DETASSELING CORN.

The removal of the male flowers from a large or small per cent. of the corn plants in a field has been experimented upon at various stations. Thus, in Maryland, where two-thirds of the tassels were removed the detasseled rows gave a decrease of nearly 10 per cent. At the Kansas Station by detasseling alternate rows of six varieties in every case there was a reduced yield averaging 22 per cent. Delaware obtained, under similar circumstances, an increase of 6.6 per cent.

Before us is the bulletin (No. 37) upon corn experiments of the Illinois Experiment Station, in which detasseling receives its share of consideration. "In eighteen out of twenty-three comparisons the yield of corn was greater for the rows (alternate) having the tassels removed. For tassels pulled we have an increase of 27 per cent. and for those cut only 6 per cent. Removed before expanding gives an increase of 11 per cent. The average increase is 13 per cent." At the Cornell Station one report (1890) was an increase of 50 per cent. for detasseling, but the next year there was no difference. The results thus far obtained teach that the end of experimentation in this direction is not yet reached.

PREVENTION OF SMUT IN OATS.

There is a large loss annually from smut in various crops, and the oat is a prominent sufferer. It was about 20 per cent. at the farm of the Ohio Station, and a fair estimate of loss for the whole United States is more than $18,000,000 annually.

This smutting of the grain, it has long been known, is due to an invading fungus that produces vast multitudes of spores in the grains; in short, the grains are transformed or replaced by the fungus, which in its final condition is mostly spores, usually dark and dusty.

Professor Selby shows by his experiments that the smut enters the seedling oat plant by spores adhering to the seed grain and may be prevented by the destruction of the spores attached to the oats before sowing. This may be done by immersing the oats in hot water at a temperature of 133° F. for fifteen minutes. This treatment likewise increases the vigor of the seed. It was also found that "soaking the seed for twenty-four hours in a three-quarter per cent. solution of potassium sulphide, made by dissolving 1½ pounds of the salt in 25 gallons of water, is equally efficient in smut prevention." But the above methods of treatment apply to wheat, barley and other grains, with certain modifications to suit the particular cases.

MUSCARDINE DISEASE OF CHINCH-BUGS.

One of the most serious of insect depredations to wheat and corn is that caused by the chinch-bug, and for years methods of checking it by employing a parasitic fungus have been the subject of research. In Kansas special appropriations have been made by the Legislature

to determine the best means of propagating and applying the virus. The latest information upon this subject comes in the shape of a sixty-page bulletin with eight plates (No. 38, March, 1895) from the Illinois Experiment Station, prepared by Dr. Forbes. The fungus experimented with is *Sporotrichium globuliferum* Speg., which was cultivated successfully upon a mixture of corn meal and beef broth, and afterwards distributed to farmers in the chinch-bug infested portions of the State.

The white muscardine (Sporotrichium) spreads most rapidly in the field when the weather is moist and the "catch" is quickest, in the low spots in the field and among fallen herbage. Professor Forbes is of the opinion that the disease may be developed without infection by artificially producing the above conditions by trampling down the grain in spots or cutting and stocking small portions as starting-points for the infection. It was observed that mites feed upon the muscardine, and in some of the artificial cultures eat up "the last vestige of the fungus." The Sporotrichium lives upon many kinds of insects, and a plate is given of the appearance of it upon the leaf skeletonizer (Carnarsia), June beetle (Lachnosterna), and walnut caterpillar (Datana).

BACTERIOSIS OF RUTABAGAS.

The number of diseases of plants of bacterial origin is rapidly on the increase, or, more strictly writing, the nature of these troubles is in these later days being better understood. A portion of Bulletin 27 of the Iowa Experiment Station is devoted to a disease of rutabagas that Professor Pammel finds, through a long course of bacteriological study, to be caused by a micro-organism which he names *Bacillus campestris* n. sp., and figures in details in a plate. This disease is distinguished by its strong odor, the decay usually beginning at the crown of the root, the fibro-vascular zone turns black, while the softer portions of the root become soft and finally watery. Healthy roots were caused to decay by introducing the bacilli, previously isolated by cultural methods, into their tissue.

POTATO CULTURE.

Within a month no less than six bulletins have been issued by as many stations upon potato culture or some phase of it.

Hastening Maturity of Potatoes.

"Hastening Maturity" is the sub-title of the one (No. 36) from the Rhode Island Station. Three methods of bringing about an earlier crop are considered, and one in detail, as it has been tested at the station. Director Flagg and Mr. Tucker write: "Maturity may be hastened in three ways—(a) By planting sets in pots in a greenhouse and transplanting to open ground; (b) by sprouting, that is, planting sets thickly in a cold frame and when ready to break ground transplanting them to the field, and (c) by budding." For the latter, small potatoes the size of hen's eggs are given heat and light for six weeks or so before planting time, thus causing a strong bud to develop and roots to form. The budded potatoes are placed in the field with the care given to onion sets, etc. A gain of 32 bushels per acre was obtained by this method over the ordinary way of planting.

Crimson Clover Good for Potatoes.

In Bulletin No. 38 of the Maryland Station, Director Miller and Mr. Brinkley find that crimson clover plowed under increased the yield, in 1894, 36, and in 1895, 50 per cent. Ridge and level culture proved of equal value, and also deep and shallow cultivation showed no difference. Spraying four times with Bordeaux mixture to prevent blight doubled the crop.

Potash for Potatoes.

At the Kentucky Station (Bulletin No. 61) Director Scovell found that potash was the most profitable commercial fertilizer to use, while the nitrates and phosphates were sometimes used at a financial loss. Several tests were made to check the scab; but here is an instance in which it is a misfortune for the enemy to fail to appear anywhere in the field, and the results are postponed thereby.

Variety-Testing of Potatoes.

Bulletin 65, Ohio Station, is devoted to the comparison of varieties of potatoes and experiments with fertilizers, by Professors Green and McFadden. They maintain that variety trials are of much value only when the sorts are tested under several sets of conditions. It is the summing up of sets of trials that brings the results of practical

importance. Thus the three varieties that have averaged highest at the central and both sub-stations in Ohio are American Wonder, Columbus and Irish Daisy. Varieties that are the least influenced by variations of soil, climate, etc., they claim are the most valuable.

Scab and Internal Brown Rot.

Professor Green, in the Minnesota Station Bulletin No. 45, reports that the subsoiling of heavy clay land increases somewhat the yield of potatoes. Considerable space is given, with engravings, to the report upon treatment for scab. The germ theory, or fungous nature of the disease, is recognized in full, for it is stated that: "Perfectly clean seed planted on land which is free from scab fungus will always and in any season produce a crop of smooth, clean potatoes, no matter what the character of the land. * * * Land infected by the germs of this disease will produce a more or less scabby crop, no matter how clean and smooth the seed is." It is recommended to dig scabby potatoes as soon as ripe, because the scab continues to grow so long as the potatoes are in the ground.

The internal brown rot works at the center of the potato, and all thus infested should be discarded as seed. The cause of this trouble is not given.

Early and Late Potato Blights.

Bulletin 113 of the Cornell, N. Y., Station, treats only of the diseases of the potato, giving several illustrations of these troubles and one coloritype plate of blight. Two leaves are shown in this, one of the "early blight," and the other of the "late blight." The former is due to the fungus *Macrosporium Solani* E. & M., and the latter to *Phytophthora infestans* De By., a downy mildew which, when affecting the tubers, produced the potato rot—an old enemy in Europe, where it has caused famines, as in Ireland in 1846. Professor Lodeman draws largely upon the literature of this blight, mentioning its rapid growth in and destruction of the attacked vines, and the disagreeable odor of the ruined potatoes. The germ tube from the spore secretes a ferment that dissolves the cell-wall of the host, and permits the parasite to pass through. The term "late blight" came from the fact that the Phytophthora does not usually appear before August. The early blight comes sooner in the season, and usually the fungus follows after some injury, frequently the

work of flea beetles. The earlier plantings of the same variety are the more affected by this blight.

Bordeaux is a satisfactory remedy for the late blight, and a promising one for the early blight.

The cause of the scab is considered and corrosive sublimate highly recommended, with the precaution that it be not used so strong as to injure the seed.

The Potato Scab.

Several Experiment Stations are making tests of various substances for the potato scab. This trouble of the potato is due to a fungus closely related to the bacteria.

Bulletin No. 33 of the Rhode Island Station gives a somewhat lengthy report of experiments that cover three years, with various chemicals. Dr. Wheeler and Mr. Tucker, the authors, state that air-slaked lime, wood ashes and calcium carbonate, calcium acetate and oxalate all increase the scab, while calcium chloride prevents it, but likewise injures the potato plant. Calcium sulphate (land plaster) is the only form of lime not harmful to the potato and fails to increase the scab. Common salt reduces the amount of scab, and this explains why seaweed is healthful to potato land when used for manure. Barnyard manure increases the scab, probably because alkaline. On the other hand, oxalic acid tends to reduce the scab. It is thought that anything which increases the acidity of the soil will reduce the scab. The scab fungus seems to multiply in the soil when the potato crop is not present. Upon acid soils practical immunity from scab has been secured for three years. Potatoes free from scab may be grown upon acid land if no barnyard manure is used.

Potato Diseases Upon Long Island.

Mr. F. C. Stewart has made a study of potato diseases, the results of which appear in Bulletin No. 101 of the New York Station. In addition to the good results following from spraying with the Bordeaux mixture for the blights, notes are given upon an internal browning of potatoes, the cause of which is not determined. The brown spots are entirely surrounded by healthy tissue, and cultures made from the discolored portions produced no growth. Under the microscope the brown spots give no clue as to the cause of the trouble, and it would seem to be physiological and not mycological in its origin. Field experiments indicate that the browning is not transmitted from

seed to product, but the discolored tubers are not the best to use for planting. There are several stem blights of potatoes, but Mr. Stewart finds another which seems to strangle the plant, and working internally, will be a difficult one to check. A new Fusarium (*F. acummatum* E. & E.) is reported.

Government Farmers' Bulletin Upon Potatoes.

In addition to the above station bulletins, the United States Department of Agriculture has issued a farmers' bulletin (No. 35) upon "Potato Culture," by Mr. Dugger, with the following subheads: Soil and rotation, manuring, varieties, planting, change of seed, size of seed pieces, distance in the row, mulching, storing, with a lengthy summary. This is a remarkably comprehensive, condensed and clear exposition of potato culture.

The impression at least is gained from the above notes that the potato is fully recognized by experimenters as a leading crop in the country and likewise a subject that is many-sided and as yet far too little understood.

TREATMENT OF PEACH ROT AND APPLE SCAB.

Delaware is a small State, but large in its peach industry. The leading enemy to the peach crop, the fruit rot, naturally is a subject that demands the attention of the Station Mycologist, Prof. F. D. Chester. For several years he has been testing various fungicides for the rotting of the fruit, and the last bulletin (No. 29), recently issued, gives both the results of the experiments and general directions for spraying. It is recommended to remove and burn all dried or mummified fruit from the peach trees in winter and spraying the trees in early spring with bluestone solution. When the fruit buds begin to swell, spray with the Bordeaux mixture, and again just before the buds open. Spray again with Bordeaux when the bloom is falling, and add a little Paris green to keep off the curculio. About two weeks later the same treatment is repeated. As the Bordeaux coats the fruit with the lime mixture, for the last two sprayings copper acetate, a colorless solution, is employed. A tenfold increase of sound fruit was obtained by this process at a cost of about twelve cents per tree.

The treatment for apple scab was the Bordeaux mixture, to which London purple had been added, and applied five times to the trees. The good fruit was doubled by this treatment, while the general health of the apple trees was much improved.

PLUM LEAF SPOT.

The camera and photo-engraving process are doing wonders for the Experiment Station bulletins. No. 98 of the New York (Geneva) Experiment Station contains five full-page process plates upon the plum leaf spot. The results of a comparative study of the value of Bordeaux mixture and Eau Celeste soap mixture are given. The Bordeaux is preferable, and the first spraying should be made soon after the bloom falls. The same treatment also lessens the attack of fruit rot. The reader needs to see the plates to be impressed with the efficiency of the sprayings, for the loss is reduced from 86.5 per cent. to 17 per cent.

In similar spraying for the leaf spot of cherry no good results are obtained. But one swallow does not make a summer and one trial is not sufficient to condemn any spraying mixture.

BACTERIOSIS OF CARNATIONS.

Bacteriosis is a term now growing into general use for the diseases in plants due to bacteria. There are several of these troubles caused by micro-organisms, but none more interesting to the mycologist than that of the carnation. Dr. Arthur and Professor Bolley conjointly have issued the results of their studies in a neat bulletin (No. 59) from the Indiana Experiment Station.

This bacteriosis is widespread among carnations, and, while seated in the leaves, checks the growth of the whole plant. The disease germs enter the plant through the stomates, punctures of insects or by dissolving a passageway in the cellulose through the action of an enzym. The methods of isolating the germs of the *Bacterium Dianthi* Arth. & Boll. n. sp. are given and a full-page heliotype plate is presented of gelatine tubes and another of the appearance of a portion of a diseased plant. It is found that any variety of carnation may be affected, but weak and old plants are most susceptible. Other than members of the pink family of plants are exempt from this trouble.

Valuable practical methods of culture to prevent the bacteriosis have been found, the chief ones residing in the fact that the disease is favored by moisture. By keeping the foliage dry, by watering the soil between rows of wire netting arranged to support the plants, the disease is largely prevented. The aphis should be kept off.

COMBATING CARNATION RUST.

The growing of carnations is a large industry in this country, but is beset with many vicissitudes, not among the least of which is the carnation rust. This trouble has been under investigation at some of the Experiment Stations, and before us lies Bulletin No. 100 of the New York Experiment Station, with the title as given above. Mr. Stewart, the author, has tested the germination of the spores of the rust fungus in various substances, and finds, for example, that a 1 to 100 solution of copper sulphate is much too weak to prevent germination. When common salt is used, 1 to 45 is the strongest solution in which the spores can grow. The spores, on the other hand, are remarkably susceptible to the action of potassium sulphide, a 1 to 3,000 solution entirely preventing germination. A similar series of results was obtained by soaking cuttings in the above solutions, those in potassium sulphide being unharmed. Attempts to cure rusty plants by spraying with fungicides failed, but good results were obtained in preventing its appearance upon healthy plants. Rust, it has been shown, will spread among mature plants. It is important that carnation plants be held up from the ground by inverted V's of wire netting. For unknown reasons, some varieties are much more susceptible than others to the rust.

DAMPING OFF.

Professor Atkinson, in Bulletin No. 94 of the Cornell Station, reports at length upon a study of microscopic fungi that work upon seedling plants in greenhouses and destroy them by what is commonly known as "damping off." This fatal result is occasioned by great moisture content of the soil, high temperatures, close rooms and insufficient light—all of which favor the growth of the low forms of fungi causing the destruction of the stems of the seedling. The conditions above given should be as far as possible eliminated. As the moulds, etc., enter the plants from the soil it is evident that the latter should be as free as may be of the germs. Diseased plants need to be thrown away and, in serious cases, the soil likewise. The soil may be sterilized by steam heating before the seeds are sown. Those who would have healthy greenhouse plants must be wise as mycologists and as loving as mothers.

RECENT APPLE FAILURES.

In another bulletin (No. 84) from the Cornell Experiment Station—and there are many and fine ones—the recent apple failures of western New York are considered by Professor Bailey. A glance at the cuts shows that failures may be due to imperfect pollination, injudicious application of fungicides, but more particularly to the ravages of the apple scab (*Fusicladium dendriticum* Fl.), of which Professor Bailey gives a full-page colored plate, showing the scab enemy in detail from the appearance of the young distorted fruit to the microscopic structure of the fungus shown in leaf sections. That the scab fungus is the leading cause of apple failures is demonstrated by the fact that thorough spraying to check it has brought productiveness. The essentials for success in apple culture, as given by the author as his concise summary, are "till, feed, prune, spray."

BLACK KNOT OF PLUMS AND CHERRIES.

The black knot fungus (*Plowrightia morbosa* Schw.) is an old orchard enemy. Professor Lodeman, in Bulletin 81 (December, 1894), Cornell Experiment Station, has given the long bibliography of the subject and shows, by means of cuts, how the spores of the fungus may find their way between the adjoining layers of bark in the forks of the small limbs. At these places the bark is thin and the growing layer (cambium) comes near to the surface, thus facilitating the inoculation. Lodgment is also produced at these angles between stems, and besides it is here that knots are most apt to form. Experiments in spraying knotty trees with Bordeaux mixture gave results that were decidedly encouraging.

ARTIFICIAL POLLINATION OF SQUASHES.

Mr. L. C. Corbitt, in his bulletin (No. 42, South Dakota Experiment Station) upon squashes, observes that in Dakata there is an abundant production of flowers of the squash plants, but "an almost complete failure of fruit." For two years he has been experimenting to find the cause, and concludes that the failure is due to an absence of insects capable of transferring the pollen from the male to the female flowers. In their absence it is further demonstrated that

profitable crops of squashes can be grown by resorting to artificial pollination. This pollination is best effected in the early morning, and consists in touching the stamens of a male flower, picked off and held in the hand to the large fleshy stigmas of the pistillate flowers, which are, of course, left on the vines. It was found that 62 per cent. of the flowers thus treated produced fruit, while practically none will grow if left dependent upon nature for the transfer of the pollen.

THE AMERICAN PERSIMMON.

A station bulletin (No. 60, Indiana) has been issued upon the persimmon, and with several full-page plates of the tree and its fruit, the subject is given a most favorable introduction. Professor Troop shows that on account of the astringent principle in the unripe fruit, the tendency of the plant to sucker, and the long time before the tree comes into bearing, the plant has been neglected. By new methods of cultivation trees may begin to bear "in three to five years from the bud or graft," and the fruit is capable of much improvement and very likely will equal the Japanese sorts, which are considered choice delicacies by many.

Under methods of propagation it is stated that, like the apple and many other standard fruits, the persimmon does not come true by seed, and therefore a variety needs to be continued by the ordinary methods, namely, by budding or grafting either of the stem or root. A plate is given showing a "top-worked" old tree, and by grafting, the comparatively worthless tree was made to bear a fine variety of persimmon.

When we bear in mind the revolution in grape culture in this country due to thorough work upon our native members of the genus Vitis, any similar study of another fruit group is welcome, fraught as it is with the possibility of adding a new fruit of no doubtful merit to our lengthening list.

ELECTRO-HORTICULTURE.

The latest results drawn from experiments with electric light upon vegetation are by Professor Rane in Bulletin No. 37 of the West Virginia Experiment Station. Investigations along this general line began in 1861, when Herve-Mango demonstrated that electric light can cause the formation of green material (chlorophyll) in plants and

produce other phenomena, as turning toward the light (heliotropism). Prilleaeux, in 1869, showed that assimilation in plants goes on in the presence of artificial light. Dr. Siemens experimented largely with arc lights, both within and at other times outside of and above the plant-houses. Professor Bailey, who at Cornell University has tested electric lighting extensively during the past few years, in reviewing Dr. Siemens' work, writes: "He used the term electro-horticulture to designate this new application of electric energy. He anticipated that in the future the horticulturist will have the means of making himself practically independent of solar light for producing a high quality of fruit at all seasons of the year. * * * Whatever may be the value of electric light to horticulture, the practical value of Siemens' experiment is still great." After years of trial, Professor Bailey stated in one of his reports: "I am convinced that the electric light can be used to advantage in the forcing of some plants."

In the fall of 1892 Professor Rane introduced the use of the incandescent light in place of the arc lamp, and his recent report, with its illustrations from photographs of plants, etc., has features of interest to all who are interested in science as well as the market-gardener. He finds that "the incandescent electric light has a marked effect upon greenhouse plants," it being "beneficial to some plants grown for foliage, such as lettuce. Flowering plants blossomed earlier and continued in bloom longer under the light" than elsewhere. Plants like spinach and endive "quickly ran to seed, which is objectionable in forcing these plants for sale. Most plants tended toward a taller growth under the light." The fact of plants responding promptly to electric light is widely demonstrated, but that it will be an economical method of growing crops is not so clearly shown.

SUB-IRRIGATION IN THE GREENHOUSE.

The Ohio Experiment Station is taking a lead in the study of irrigation under glass, by Prof. W. J. Green. In a recent bulletin the construction of the greenhouse with iron frames and bench-tiles is fully shown by engravings, as also the great difference in the size of lettuce grown with sub-irrigation and surface-watering, it being twice as large with the former as the latter method. The idea of irrigating below the surface grew out of an attempt to prevent the rotting of lettuce by not wetting the foliage. Sub-irrigation is cheaper

than the old method of surface-watering; the soil remains in a better condition, and the plants are less liable to decay. These results come largely from the soil, permitting the air to pass freely through it, besides supplying water constantly to the roots.

PLANTS THAT LOOK LIKE THE RUSSIAN THISTLE.

In Bulletin No. 39 of the Illinois Experiment Station, Mr. Clinton, the Assistant Botanist, brings out by means of text and engravings, some of the plant rogues that resemble the Russian thistle.

Among those of special mention are the winged pigweed (*Cycloloma atriplicifolium* (Spreng.) Coult.), one of the plants of the plains. It is easily distinguished from the Russian thistle by its flat leaves of the ordinary sort. In the autumn this plant, by breaking away from the soil at the root, becomes one of the noted "tumble weeds." Another species of weed quite closely related to the last, and likewise a "tumbler," is the *Amarantus albus* L. It is not confined to the West, but may be found in many an Eastern neglected field. This amaranth has a first cousin that is spinose (*A. spinosus* L.), and for this reason is easily mistaken for the Russian pest. Somewhat more remote as regards botanical relationship is the horse nettle (*Solanum Carolinense* L.), which is akin to the tomato, egg-plant and potato. It has yellow prickles and berries. The Texan horse nettle or "sand bur" is even worse than the last, to which it is closely related. It is *Solanum rostratum* Dun. Of course it would be a fault of omission not to mention the Canada thistle in this connection, as it is one of the most despised of the prickly weeds. There is a prickly lettuce (*Lactuca Scariola* L.), common in the West, that resembles the Russian intruder, but easily distinguished from it by the flat leaves, which are polar, and the species is a compass plant.

WEED SEEDS IN WINTER WINDS.

It is well known that winds play an important role in the distribution of seeds. Professor Bolley, in the North Dakota Experiment Station Bulletin No. 17 (March, 1895), records that in two square feet of a three-weeks-old and three-inch-deep snow drift upon an ice pond ten yards from any weeds he found 19 weed seeds, and in

another drift quite similarly situated 32 seeds, representing 9 kinds of weeds. While the wind was blowing twenty miles per hour a peck of mixed seeds was poured upon the snow crust, and ten minutes after, 191 wheat grains, 53 flax seeds, 43 buckwheat and 91 ragweed seeds were found in a trench 30 rods from where they had been poured upon the crust.

LEGISLATION AGAINST WEEDS.

The Division of Botany, United States Department of Agriculture, has issued a bulletin (No. 17), prepared by Mr. L. H. Dewey, "in response to a growing demand among agriculturists and legislators for data which will enable them to prepare laws better adapted for the control of weeds than those now in use." One per cent. of increase in the crops, which might be obtained by weed destruction without much cost, would amount to $17,000,000. The passage of proper laws against weeds is important and should be effected with dispatch.

The weed laws are listed as found upon the statute-books of the following States: Arizona, California, Connecticut, Delaware, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Michigan, Minnesota, Missouri, Nebraska, New Jersey, New York, North Dakota, Ohio, Oregon, Pennsylvania, South Dakota, Vermont, Washington, West Virginia, Wisconsin. Thus twenty-five States and Territories have laws against weeds. In some States the law is to suppress but a single species, as against Canada thistle in California, Delaware, Kentucky, while other States proscribe fourteen, as in Minnesota and Ohio. The largest proscription is with the Canada thistle, twenty-one out of twenty-five States. Six States legislate against the Russian thistle.

That there is no federal law against weeds is probably due to the fact that no one species is national in importance, but the Russian thistle may become such if it spreads as it is feared.

The basis for a general weed law is given, and includes as a leading feature a commission of which the State Botanist shall be the head. It is very important that new weeds shall be recognized and measures taken to eradicate them at once. Legislation for the purity of seeds will do much to check the introduction of weeds as foul stuff in commercial seeds.

REPORT

OF THE

BOTANICAL DEPARTMENT

OF THE

New Jersey
Agricultural College Experiment Station,

BY

BYRON D. HALSTED, SC.D.,

For the Year 1897.

TRENTON, N. J.:
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1898.

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CONTENTS.

REPORT OF THE BOTANIST.

REPORT OF THE BOTANIST.

In the Botanical Department the work for the year ending November 30th, 1897, has been divided between the field experiments at the College Farm and elsewhere in the State, and laboratory investigations with the microscope.

The chief lines in the field have been with fungicides upon turnips, beets, potatoes, tomatoes, peppers, beans, spinach, egg-plants, onions, cucumbers, peas and various ornamental plants.

Sweet potato soil rot has been further studied, especially with a mixture of sulphur and kainit.

Pear fire blight is being investigated in an orchard put at the service of the Experiment Station for five years.

In the greenhouse violet troubles are under consideration, and there also the peach root gall has been further studied.

The work with weeds has been continued and an experiment made with them in their influence upon crop and soil.

The herbarium has been enlarged by a few hundred specimens within the year, and a display case of plant diseases is started.

Since the last report was issued, Bulletin No. 120, "Field Experiments with Potatoes for 1896," has been published.

Mr. James A. Kelsey, as field assistant, has had charge of the details of the experiments at the College Farm, and has aided greatly in the preparation of this report. Mr. F. A. Blodgett, a graduate student in botany, spent the summer vacation assisting in the work upon the Experiment Area.

The Experiment Area.

The area devoted to experiments under the charge of the Botanist embraces nearly two acres. For two years previous to 1896 the area was one acre, and was plotted as shown for Series I. to V., inclusive, in Figure 1. Extensions were made two years ago upon both the right and left ends of the original acre, but the plots and belts have not been changed in any way from the time they were laid out in 1894.

The Experiment Area.

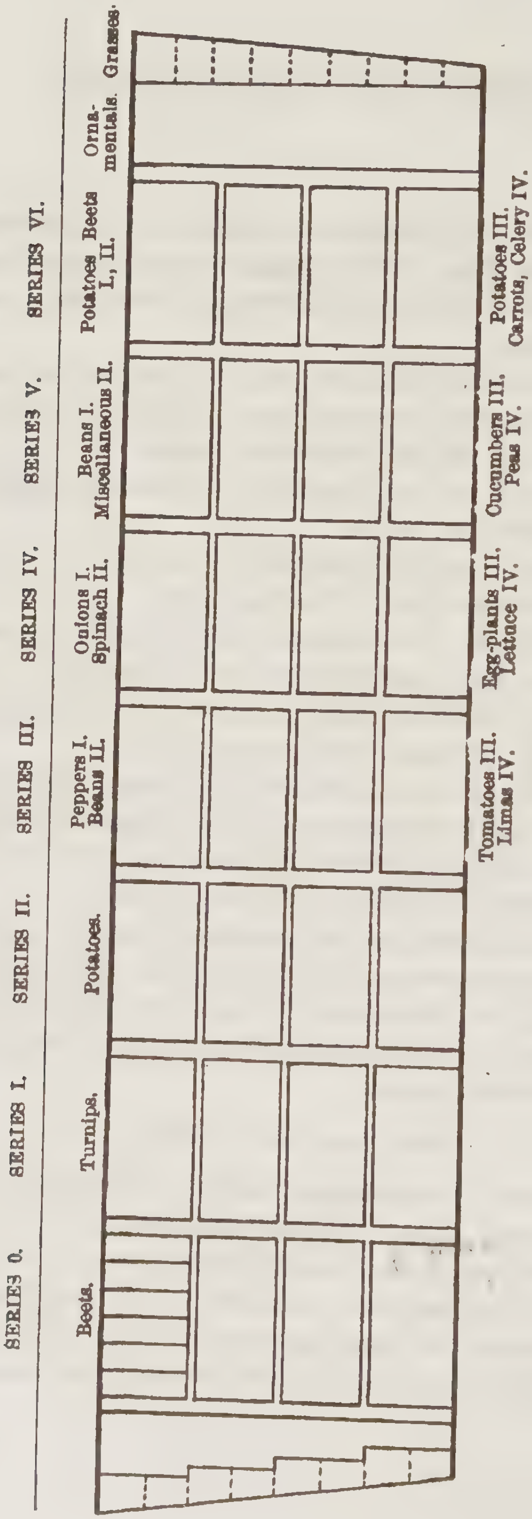

Fig. 1.
The Experiment Area in 1897.

Fig. 2.

View of Experiment Area from Upper Story of Office Building, [illegible]

In the first acre there were five series, each divided into four plots and each plot into six belts.* In 1896 a series was added to the east or left hand, as seen in the plan, Figure 1, and one at the west or right hand. In order to retain the old numbers for the old series, the new ones are known as Series 0 upon the east and Series VI. upon the west end.

Upon the left of Series 0 there is a strip of land that is used for various purposes, some of it being in young chestnut, maple, horse-chestnut and peach trees. Here, in a strip of the width of a belt (11 feet) and adjoining Series 0, the weed experiment with beets was carried out.

To the right of Series VI. is a considerable space devoted to experiments with ornamental plants, and between this and the roadway nine experimental grass plots, placed side by side, form the western border to the Experiment Area.

Just across the roadway from the grass plots is the office and tool-room, fitted up during the present year, and adding greatly to the convenience of all engaged in the experiments. Figure 2 gives a view of the Experiment Area from above the office.

Ordinary stable manure from the College Farm barns, at the rate of twenty tons per acre, has been applied uniformly over the whole area under experimentation for each of the past four years. No other fertilizer has been used at any time except as when kainit, wood-ashes, etc., were employed as possible fungicides upon certain belts in the plots.

EXPERIMENTS WITH TURNIPS.

The purpose of the experiments with turnips since 1894 has been to determine a satisfactory preventive of the destructive disease commonly known as club-root, caused by the fungus *Plasmodiophora Brassicæ* Wor.,† and common to the cabbage and several other members of the mustard family of plants.

Series I. of the experiment area has been in turnips for the past four years, and the results of the same recorded in the reports for the

* The series are separated from each other by four-foot paths, and the plots in each series by two-foot spaces. Each plot is 33 x 66 feet, and is divided crosswise into six belts, each 11 x 33 feet. Each plot is one-twentieth, and each belt one one-hundred-and-twentieth of an acre. This arrangement is given in detail in the report for 1894, page 278.

† For a description of the disease under consideration, the reader is referred to Bulletin No. 98, "Club Root of Cabbages and Its Allies."

Station for 1894, pages 278–285; 1895, pages 250–267; 1896, pages 294–309, and those for the present season are given below.

In order that the reader may know the treatment each belt received during previous years, the accompanying plan (Figure 3) has been constructed. This gives the soil applications in terms of per acre, and

	Belt 1.	2.	3.	4.	5.	6.
Plot I.	1894. Lime, 300 bushels.	1896. Sulphur, 800 pounds.	1894. Lime, 150 bushels.	Nothing. 1895. 2d crop Irrigated. 1897. Allied plants.	1894. Lime, 75 bushels. 1896. Irrigated.	1894. Corrosive sublimate, 5,280 gallons. 1895 (Nov). Blighted tops 1897. Corrosive sublimate, 5,280 gallons.
Plot II.	1894. Gas-lime, 150 bushels. 1897. 1st crop Lower third shaded.	1895. Corrosive sublimate, 83¾ pounds.	1894. Gas-lime, 75 bushels 1897. Allied crucifers.	Nothing. 1897. 2d crop. Lower third shaded.	1894. Gas-lime, 87½ bushels, 1896. Irrigated. 1897. 1st crop. Upper half buckwheat, lower half fallow.	1894. Bordeaux, 5,280 gallons. 1895. Corrosive sublimate, 16⅞ pounds.
Plot III.	1894. Kainit, 1,920 pounds. 1896. Sulphur, 600 pounds.	1895. Copper Sulphate, 1,200 pounds	1894. Kainit, 960 pounds. 1897. (August). Salsoda. 120 bushels.	Nothing. 1896. 2d crop Irrigated.	1894. Kainit. 480 pounds. 1896. 1st crop Irrigated. Carbonate of lime (June). 60 bushels.	1894. Cupram, 5,280 gallons. 1895. Copper sulphate, 600 pounds. Roots (Nov.)
Plot IV.	1894. Ashes, 300 bushels. 1896. Sulphur, 1,200 pounds	1894 (Nov.) Lime, 600 bushels.	1894. Ashes, 150 bushels, 1895 (July). Salt, 600 pounds.	1894 (Nov.) Lime, 300 bushels.	1894. Ashes, 75 bushels. 1895 (July). Salt, 300 pounds. 1896, 1st crop Irrigated. Salsoda (June) 60 bushels.	Nothing. 1897. Cabbages.

Fig. 3.

Plan of Turnip Experiments for 1897.

it is to be understood that they were made in the Spring unless otherwise indicated. The year, as 1894, etc., is followed by whatever is added during that time and no mention is made of the year when there was nothing applied.

During 1897 there was no experiment in irrigation with turnips and no changes in Plot I. except the use of belt 4 for the growth of a long list of plants that, while not in the turnip order of plants (*Cruciferæ*), are closely related to it. This was to determine the breadth of range of susceptibility in plants to the club-root fungus (*Plasmodiophora Brassicæ* Wor.) Belt 6 had the application of corrosive sublimate of 1894 repeated.

In Plot II. shade was used upon one-third of belt 1; plants of the same family as the turnip were grown in belt 3, and belt 5 was one-half sowed to buckwheat and the other half left fallow for the first crop, the attempt being to determine the effect, if any, of buckwheat upon the clubbing in the turnips that followed it.

In Plot III. there was no change for the first crop, but for the second, belts 1 and 2 were sown to various clovers, as this land has reached such a condition that turnips would scarcely grow upon it, due in part to the large amounts of chemicals that had been used. Belt 3 had salsoda added before the second crop, at the rate of 120 bushels per acre.

Plot IV. remained unchanged, except that belt 6 was used for an experiment with cabbages.

Instead of the single variety as heretofore grown, seeds of seven widely-separated types of turnips were sown upon each belt, beginning upon the left side of each belt as seen in the plan and in the following order: (1) Purple strap leaf, (2) yellow Aberdeen, (3) rutabaga, (4) snowball, (5) golden ball, (6) white cowhorn, (7) scarlet kashmyr.

	Belt 1.	2.	3.	4.	5.	6.	
Plot I.	49.75 lbs. .25	18.87 40.06	68.06 1.	Allied plants.	59.56 8.18	65.81 27.	Sound. Clubbed.
Plot II.	86.75 4 18 8 Shade.	4 83	Allied crucifers.	8 81.87	Upper half buckwheat. Lower half fallow.	87 81,05	Sound. Clubbed.
Plot III.	4.06 15.87	8.45 9	8.75 20.12	4.06 27.75	82.06 81.62	12.87 58.56	Sound. Clubbed.
Plot IV.	17.5 59.	67.87 18.5	45.87 75.87	62 62 27.87	87.56 48	Cabbages.	Sound. Clubbed.

Fig. 4.

Results of First Crop of Turnips.

For the present the idea of several varieties will be overlooked and the belts compared with each other as in previous years.

Lime has been used in five belts, namely, 1, 3 and 5 of Plot I. and belts 2 and 4 of Plot IV. These gave a total of 302.36 pounds of clean roots to 50.80 pounds affected with club-root, and all but 4.43 pounds of this whole amount is in the lowest plot, where there is often considerable surface-washing from the plot above, which may fully account for the less-marked success here than in Plot I. The carbonate of lime, at the rate of 60 bushels per acre, in belt 5, Plot III., where previously the clubbing had been very bad, showed a little more than half sound roots, and salsoda, at the rate of 60 bushels per acre, upon belt 5, Plot IV., where clubbing had been almost universal, gave 37.56 pounds of sound roots to 43 pounds of those that were clubbed.

Only two belts now remain of all the twenty-four that have not received some treatment, and these two checks gave 8 and 4.06 pounds of sound roots to 31.87 and 27.75 pounds respectively of clubbed roots.

Three belts received sulphur, in the Spring of 1896, at the rate of 300, 600 and 1,200 pounds, and the sound roots are respectively 18.87, 4.06 and 17.5 pounds, and the clubbed ones 40.06, 15.37 and 59 pounds. In other words, there were 40.43 pounds of sound roots to 114.43 of clubbed turnips.

The three belts in which corrosive sublimate was used gave of sound roots 65.31, 4 and 37 pounds respectively as against 27, 33 and 31 pounds of clubbed turnips; that is, there was about a half of each. Such results are not encouraging for this substance, when lime has proved remarkably effective for eight successive crops upon the same land after a single application.

It is to be noted that none of the other substances, as kainit, copper sulphate, Bordeaux or cupram, have proved of value as a check upon the club-root fungus.

Second Crop of Turnips.

Series I. was again sown to turnips upon August 18th, and harvested upon November 5th and 6th. In the table given below of the weights of roots, sound and clubbed by belts, it is seen that the results agree quite closely with those of the first crop. The five limed belts gave a total of 341.5 pounds sound to 2.75 pounds of clubbed roots. This is an increase of sound roots over the first crop and a large falling off of the clubbed ones. The carbonate of lime

	Belt 1.	2.	3.	4.	5.	6.	
Plot I.	61.75 lbs.	15.5	51.5	Allied	65.25	86	Sound.
	.5	41.25	.25	Plants.	.75	17.75	Clubbed.
Plot II.	56.5	9.5	Allied	12 28	Buckwheat, 1st crop. 86 6.5	39.75	Sound.
	3.5	33.75	Crucifers.	2.75 4.75 Shade.	Fallow, 1st crop. 7.5 5.5	25.5	Clubbed.
Plot III.	Leguminous Plants.		3.25	5	37	6.75	Sound.
			3.5	22.25	10.75	15.75	Clubbed.
Plot IV.	14.75	77.5	40	79.5	18	Cabbages.	Sound.
	29.50	1.25	41.5	0	20 25		Clubbed.

Fig. 5.
Results of Second Crop of Turnips.

in this gave much better results than in the first crop, while the belt receiving the salsoda retains nearly the same ratio between the sound and clubbed roots.

One of the two checks carried the experiment with shade, and the exposed two-thirds reduced to terms of a whole belt gives 12 of sound roots and the second check belt 5 pounds, which is more sound roots for the two than in the first crop, and a much greater relative amount, since the total yield is smaller for the second than the first crop in all parts of the series.

One of the three belts receiving sulphur was sown to clovers, and the other two gave a total of 29.75 pounds of sound to 70.75 of clubbed roots, or nearly the same ratio as for the first crop, and no better than the checks.

The three belts in which corrosive sublimate was used gave 86, 9.5 and 39.75 pounds of sound roots, respectively, to 17.75, 33.75 and 25.50 pounds of clubbed roots, which is a little better result than in the first crop, but gives no encouragement. None of the other substances, as kainit, copper sulphate, Bordeaux or cupram, show any favorable results.

Before closing this feature of the results, it may be noted that belt 1, Plot II., which had gas-lime, 150 bushels per acre, in 1894, while slower than the lime alone, has nearly eradicated the club-root fungus, the last crop being 56.5 pounds of sound to 3.5 of clubbed roots.

Susceptibility of Varieties of Turnips to Club-Root.

As before mentioned, seven varieties of turnips were grown upon each belt, instead of a single sort, as in former years, that a test might be made of the susceptibility of these varieties to the club-root fun-

Fig. 6.
A Clubbed Turnip Root of (1) Strap Leaf, (2) Aberdeen, (3) Rutabaga, (4) Snowball, (5) Golden Ball, (6) Cowhorn, (7) Kashmyr.

gus. Figure 6 gives the appearance of a clubbed root of each sort as found in the first crop.

The two following tables give the total sound and clubbed roots in pounds for each variety, together with the total weights, per cent. of

clubbing, and the rank of each sort derived from the percentage of diseased roots:

	Sound.	Clubbed.	Totals.	Per cent. clubbed.	Rank.
Purple strap leaf	123.75	78.25	202	38.73	5
Yellow Aberdeen	80	50	130	38.46	6
Rutabaga	41	108	148	72.48	1
Snowball	79	112	191	68.64	2
Goldenball	102	66	168	39.28	4
White cowhorn	115	96	211	45.49	3
Scarlet kashmyr	106	46	152	30.26	7
				46.19	

Fig. 7.

Totals of First Crop by Varieties.

	Sound.	Clubbed.	Total.	Per cent. clubbed.	Rank.
Purple strap leaf	134.75	54.75	189	28.93	5
Yellow Aberdeen	61.75	22	83	26.50	6
Rutabaga	50.75	41.25	92	44.83	1
Snowball	95	52	147	35.44	2
Goldenball	105	41	146	28.08	4
White cowhorn	88	42.50	130.5	32.56	3
Scarlet kashmyr	144.75	33.25	178	18.45	7
				30.68	

Fig. 8.

Totals of Second Crop by Varieties.

It is seen that there is only about two-thirds as much clubbing in the second crop as in the first, but the rank in disease is the same for all the varieties in both crops. The rutabaga is clubbed to the greatest extent (72.48 per cent. and 44.83 per cent.), and this excess of disease is associated with the variety that abounds in branching fibrous roots that reach widely through the soil. Upon the other hand, the scarlet kashmyr almost sits upon the surface of the soil, and, as the record shows, is the least affected, namely 30.26 per cent. for the first and 18.45 per cent. for the second crop.

The form of the root, the character of the root system, whether it is much branched or not, and the position of the turnip in or above the soil, as considered in connection with the results given in the tables, leads to the opinion that the susceptibility to club-root depends largely upon peculiarities of the root itself. The suggestion therefore follows that, other things remaining the same, the turnip that is most superficial in its growth in the soil may be the one least susceptible to clubbing, and therefore to be chosen in localities where there is danger from the *Plasmodiophora*.

Influence of Buckwheat upon Turnip Land.

There is an opinion quite generally entertained by farmers that buckwheat has a marked effect upon the soil where it is grown, some going so far as to claim that it acts as a poison upon crops that succeed it. In order to test the effect, if any, of this crop upon turnips the upper half of belt 5, Plot II. was sown to buckwheat at the time the first crop of turnips was put in elsewhere, while the lower half of the belt was left fallow. When the buckwheat was ripening its seed the plants were run through a feed-cutter, and the chopped stems spread upon and spaded into the soil from which the buckwheat had been removed. Young plants from the seed of the first crop soon came up and the ground was again covered with buckwheat, and this young crop was spaded in and the ground sown to turnips along with the other parts of the series. The fallowed half of this belt was spaded and otherwise treated in the same way as the half belt above it, excepting the single difference of not having the buckwheat grown upon it.

The only previous treatment this belt has received was gas-lime, in 1894, at the rate of 37½ bushels per acre.

All through the growing period of the turnips succeeding the buckwheat there were great differences observed. The fallowed half produced only small plants, and the crop harvested was of sound roots, only 7.5 pounds and 5.25 of clubbed ones. The half where buckwheat was grown yielded 36 pounds of sound and 6.5 of clubbed roots.

It is seen from these figures that the crop of sound roots was five times increased upon the buckwheat land, while there was a total of only 1.75 pound of increase of clubbed roots. The test is not upon a large enough scale to warrant drawing any conclusion, but it would seem that buckwheat has a wholesome effect upon soil that is "turnip sick" from the presence of the club-root fungus.

Shading of Turnips.

One-third of belt 1, Plot II., was shaded for the first crop and in terms of full belts yielded 13 pounds of sound roots and 3 pounds clubbed, while the exposed gave 36.75 and 4 pounds respectively. For the second crop the shade was transferred to a check belt (4) of the same Plot (II.), where the results were for shaded ground 2.75 pounds sound and 4.75 clubbed roots, while the exposed soil gave 12 pounds of sound and 28 of clubbed roots. The season's experi-

ments with shading seem to indicate that the club-root fungus is practically as active in a half-shaded soil as in that which is wholly exposed.

"Scabbing" of Turnips.

A sort of scurf has been noted upon certain turnip roots in previous crops and the degree of marking has gradually increased during the past four years. Turnips infested in this manner only have not been included among the clubbed roots, but since they resemble very much in appearance scabby potatoes or beets, such roots have been classed as "scabbed." A much larger amount of "scab" has been observed in Plot I. than elsewhere, there being much less than in Plot II., while Plots III. and IV. were practically uninfested. In the first plot it has been noted that the percentage of "scab" is considerably greater in the limed belts than in those treated with sulphur or corrosive sublimate. Of the seven sorts of turnips grown the present season the yellow Aberdeen, early snowball and long cowhorn were "scabbed" considerably more than were the other four varieties.

EXPERIMENTS WITH OTHER CRUCIFERÆ.

In belt 3, Plot II., the seeds of thirty-four kinds of plants belonging to the mustard family were sown for the purpose of determining the relative susceptibility of the various plants that are members of the same group as the turnip.* The following is the list:

1. *Alyssum maritimum* L.
2. *Alyssum saxatile* L.
3. *Iberis umbellata* L.
4. *Lunaria biennis* L.
5. *Erysimum Perofskianum* Fisch. & Mey.
6. *Erysimum asperum* D. C.
7. *Mathiola incana* R. Br.
8. *Mathiola bicornis* D. C.
9. Watercress
10. Australian cress.
11. Upland cress.
12. American cress.
13. Extra curled cress
14. Radish, long black Spanish.
15. Radish, long scarlet short top.
16. Radish, early scarlet turnip.
17. Radish, round dark red.
18. Radish, giant Stuttgart.
19. Radish, Newcom white.
20. Radish, Sandwich.
21. Radish, long white Vienna.
22. Radish, yellow summer turnip.
23. Radish, early white turnip.
24. *Lepidium intermedium* Gray.
25. *Lepidium Menziesii* D. C.
26. *Arabis Canadensis* L.
27. *Arabis glabra* (L.)
28. *Arabis brachycarpa* (T. and G.)
29. *Isatis tinctoria* L.
30. *Lepidium montanum* Nutt.
31. *Sisymbrium officinale* Scop.
32. *Sisymbrium altissimum* L.
33. *Sophia pinnata* (Walt.)
34. *Roripa Armoracia* (L)

*A similar list of wild and cultivated mustards was grown upon the same belt in 1896, an account of which may be found in the Annual Report for that year, pages 308, 309.

In the above list the crucifers most severely clubbed were numbers 5, 6 and 25. Plants of these three species were frequently destroyed by the disease, and the growth of nearly all was materially retarded. Upon none of these three species has club-root been heretofore recorded, so far as can be determined. The roots of numbers 1, 16, 17, 20, 21, 23 and 31 were found to be occasionally clubbed, but in no case was the injury sufficient to seriously harm the plant. Those whose roots seemed wholly free from clubbing were numbers 4, 7, 9, 10, 11, 12, 13, 14, 15, 18, 19, 22, 26, 27, 28 and 34. Owing either to the failure of the seed to germinate or to the early destruction of the seedlings, it was impossible to determine the susceptibility of the roots of numbers 2, 3, 8, 24, 29, 30, 32 and 33.

The investigations thus far with cruciferous plants have shown that while there is a large group of wild and cultivated species that is very susceptible to the club-root, there is another which, although its members may be occasionally attacked, can be grown in badly-infested soil without being seriously injured.

Testing Allied Plants for Club-Root.

In belt 4, Plot I., plants allied to the mustard family were grown, the purpose being to determine if plants outside of the family to which the turnip belongs are susceptible to the club-root fungus. The following kinds of seeds were sown, each sort occupying a row running across the belt:

1. *Ranunculus bulbosus* L.
2. *Chelidonium majus* L.
3. *Papaver Sp.* (Cult.)
4. *Argemone Mexicana* L.
5. *Cleome spinosa* L.
6. *Reseda odorata* L.
7. *Saponaria officinalis* L.
8. *Silene noctiflora* L.
9. *Agrostemma Githago* L.
10. *Hypericum perforatum* L
11. *Abutilon Abutilon* (L.)
12. *Hibiscus Trionum* L.
13. *Malva rotundifolia* L.
14. *Erodium cicutarium* (L.)
15. *Crotalaria sagittalis* L.
16. *Medicago lupulina* L.
17. *Melilotus alba* Desv.
18. *Agrimonia hirsuta* Muhl.
19. *Heuchera sanguinea* Engelm.
20. *Onagra biennis* (L.)
21. *Phytolacca decandra* L.

The seed of numbers 1, 5, 10, 15, 16, 18, 19, 20 and 21 of the above list failed to germinate, but of the remaining species vigorous specimens were obtained, the roots of which were occasionally examined during the summer, and all that remained were dug up and inspected at the close of the season. No indication of club-root was detected in any of the species.

EXPERIMENTS WITH CABBAGES.

The check belt (No. 6) of Plot IV. of the turnip series was given the present season to an experiment with cabbages. This land having been in turnips and untreated had become so badly infested with the club-root fungus that turnips in the first and second crops of 1896 were 98.75 and 100 per cent. clubbed, respectively.

Cabbage seed, Early Jersey Wakefield, was sown through the middle portion of this belt, and also a quantity of the same lot of seed in belt 2 of the same plot where the land had received lime at the rate of 600 bushels per acre. Upon June 10th, when the plants were three weeks old, they were all removed from the belt and four rows of eighteen plants each were set out. Two of these rows were set with plants that had been grown in the limed land and the other two alternating rows with plants that were grown upon the check belt under experimentation.

At the time of setting, one hundred other plants from the limed soil were washed and their roots examined, when it was found that none of them were clubbed. One hundred and thirty of those from the untreated belt were similarly examined and fifteen were more or less clubbed. In other words the plants in the limed soil had up to that time developed no signs of club-root, while in the untreated soil nearly 12 per cent. showed the disease.

The cabbage plants, as they stood in the four rows, developed so unequally that any person in passing would have noticed the difference. The two rows planted from the lime land were taller and in every way more vigorous than those in the two alternating rows set from the untreated soil. This difference did not continue, however, to increase, and as the time for harvest, August 18th, approached all showed a feebleness that indicated the presence of the club-root in all plants. In terms of heads, all of which were small, the two rows from the limed land yielded twelve heads each, while the other two had seven and three heads respectively. In short, the actual yield in pounds was as three to one in favor of the plants from the limed soil, the exact figures being 28¾ to 9½ pounds.

In another part of the Experiment Area, Series V., Plot II., belts 3 and 4, where turnips had not been grown since 1893, a similar test of the influence of soil upon seedling cabbages was made. Here a whole belt was set, seventy-two plants, from the limed land and an

adjoining belt with plants from the untreated land. The two belts were treated alike and, in order to test the soil as to its having the club-root germs, turnip seed was sown between the rows of cabbages throughout the two belts. These plants were examined from time to time and it was determined thereby that this land, that had not been in turnips for four years, still had an abundance of germs and the turnips were generally clubbed.

At the harvest of cabbages the number of heads upon the belt set with plants from the limed land was twenty-six, those from the untreated land twenty, and their respective weights were 43½ and 28½ pounds.

Here, as in the first portion of the seedling test with cabbages, it is seen that the early growth of the plants from the seed in a soil free from the club-root germs has a marked effect upon the crop, more than doubling it when an average is made of the two tests above recorded.

The experiment indicates that the probable time when plants are most susceptible is when they are small, and if this can be passed free from exposure to the germs of the disease much has been done to insure the crop. Growers of cabbages may be able to protect their cabbage plants from club-root by growing them in a virgin soil or one that has been limed. On the other hand, they may greatly reduce their profits if their young plants are propagated in a soil selected without care or forethought and containing an abundance of the club-root germs.

EXPERIMENTS WITH POTATOES.

For the last four years Series II. of the Experiment Area has been devoted to potatoes, the effort being to obtain a satisfactory remedy for the potato scab (*Oospora scabies* Thax.)*

There were a few changes made in the plan of the previous year. In Plot I. the belt remained the same, but in Plot II. one-third of belt 1 was shaded; plants allied to the potato were grown in belt 4 to determine whether their roots would become scabbed. Oxalic acid, one pound in 36 gallons of water, was added to belt 5, and standard Bordeaux, 36 gallons, was again added to belt 6. Plot III., belt

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*The reader will find in Bulletin No. 112 a general description of this pest, with an engraving of a badly-scabbed potato. He may also consult reports 1894, pages 291–295; 1895, pages 267–275, and 1896, pages 309–319, giving details of these experiments for the last three years.

	Belt 1.	2.	3.	4.	5.	6.
Plot I.	1894. Lime, 300 bushels 1895. Scabby, 100 per ct. 184 pounds. 1896. Scabby, 75 per ct. 88 pounds.	1895. Seed soaked 1 hour in corrosive sublimate (1–500). Scabby, 100 per ct. 115 pounds. 1896. Sulphur, 120 pounds. Scabby, 50 per ct. 76 pounds.	1894. Lime, 150 bushels. 1895. Scabby, 100 per ct. 108 pounds. 1896. In turnips and beets.	1895. Nothing. Scabby, 97 per ct. 126 pounds. 1896. (Early Rose). Scabby, 85 per ct. 55 pounds.	1894. Lime, 75 bushels. 1895. Scabby, 98 per ct. 188 pounds. 1896. Irrigated. Scabby, 75 per ct. 76 pounds.	1894. Corrosive sublimate (1–1,000), 4,320 gallons. 1895. Scabby, 80 per ct. 108 pounds. 1896. Corrosive sublimate (1–1,000), 4,320 gallons. Scabby, 10 per ct. 81 pounds.
Plot II.	1894. Gas-lime, 150 bushels. 1895. Scabby, 100 per ct. 105 pounds. 1896. Scabby, 75 per ct. 109 pounds. 1897. Lower third shaded.	1895. Seed soaked 1 hour in corrosive sublimate (1–1,000). Scabby, 100 per ct. 70 pounds. 1896. Sulphur, 240 pounds. Scabby, 50 per ct. 109 pounds.	1894. Gas-lime, 75 bushels. 1895. Scabby, 100 per ct. 108 pounds. 1896 Kainit, 600 pounds. Scabby, 45 per ct. 88 pounds.	1895. Nothing. Scabby, 100 per ct. 108 pounds. 1896. Scabby, 70 per ct. 75 pounds. 1897. Allied Solanums.	1894. Gas-lime, 87½ bushels. Scabby, 100 per ct. 90 pounds. 1896. (Am. Giants). Irrigated. Scabby, 50 per ct. 25 pounds. 1897. Oxalic acid, 120 pounds.	1894. Bordeaux, 4,320 gallons. 1895. Scabby, 70 per ct. 107 pounds. 1896. Bordeaux, 4,320 gallons. Scabby, 50 per ct. 64 pounds. 1897 Bordeaux, 4,320 gallons.
Plot III.	1894. Kainit, 1,920 pounds. 1895. Scabby, 100 per ct. 183 pounds. 1896. Scabby, 85 per ct. 92 pounds. 1897. Large-rooted weeds.	1895. Seed soaked 1 hour in corrosive sublimate (1–2,000). Scabby, 100 per ct. 186 pounds. 1896. Sulphur, 600 pounds. Scabby, 65 per ct. 88 pounds.	1894. Kainit, 960 pounds. 1895. Scabby, 100 per ct. 126 pounds. 1896. Kainit, 1,200 pounds. Scabby, 70 per ct. 19 pounds.	1895. Nothing. Scabby, 100 per ct. 144 pounds. 1896. (Am. Giants). Scabby, 75 per ct. 34 pounds.	1894. Kainit 480 pounds. 1895. Scabby, 100 per ct. 126 pounds. 1896 Irrigated. Scabby, 85 per ct. 107 pounds. 1897. Kainit, 300 pounds. Sulphur, 300 pounds.	1894. Cupram, 4,320 gallons. 1895. Scabby, 80 per ct. 104 pounds. 1896. Cupram, 4,320 gallons Scabby, 75 per ct. 87 pounds. 1897. Sweet potatoes.
Plot IV.	1894. Ashes, 300 bushels. 1895. Scabby, 100 per ct. 131 pounds. 1896. Seed soaked 2 hours in corrosive sublimate (1–500). Scabby, 90 per ct. 69 pounds. 1897. Sulphuric acid, 120 pounds.	1895. Seed soaked 1 hour in corrosive sublimate (1–4,000). Scabby, 100 per ct. 188 pounds. 1896. Seed rolled in sulphur. Scabby, 90 per ct. 99 pounds. 1897. Corrosive sublimate, (1–4 000) 36 gallons	1894. Ashes. 150 bushels. 1895. Scabby, 100 per ct. 126 pounds. 1896. Seed soaked 2 hours in kainit (1–100). Scabby, 80 per ct. 67 pounds. 1897. Kainit, 200 pounds. Sulphur, 2[illegible]0 pounds.	1895. Nothing. Scabby, 100 per ct. 116 pounds. 1896. Scabby, 90 per ct. 90 pounds. 1897. Cultivated root crops.	1894. Ashes, 75 bushels. 1895. Scabby, 100 per ct. 120 pounds. 1896. (Early Rose). Irrigated. Scabby, 100 per ct. 84 pounds.	1895. Sulphur, 300 pounds. Scabby, 5 per ct. 101 pounds. 1896. Scabby, 5 per ct. 82 pounds.

Fig. 9.

Plan of Potato Experiments for 1897, giving results for 1895 and 1896.

1, was sown with seeds of large-rooted weeds; sulphur and kainit, each 2.5 pounds, was added to belt 5, and sweet potatoes of six different varieties were grown in belt 6, to determine whether this root crop would be attacked by the scab fungus. In Plot IV. sulphuric acid, one pound in 36 gallons of water, was added to belt 1, and to belt 2 corrosive sublimate, 36 gallons, of 1 to 1,000 strength. Sulphur and kainit, 1.66 each pound, was applied to belt 3, while belt 4 received a considerable number of root crops. The planting was made upon April 24th.

The record of the treatment each belt received in all the plots is made in Figure 9 on the preceeding page.

Three varieties of potatoes were planted April 24th in each belt, namely, "Early Rose," "Rural No. 2," and the "American Giant." The soil conditions were unfavorable for growth, and with the "Rural" appearing first, it was a full month before the plants were all up, and at that time, May 24th, the "American Giants" were the smallest of all. The stand of plants was poor, and the yield small at time of harvest, August 30th–31st—somewhat earlier than usual, due to the late blight (*Phytophthora infestans* De By.), which developed with great rapidity during the latter half of August. The yield by belts is given below:

Plot I.	Belt 1.	Belt 2.	Belt 3.	Belt 4.	Belt 5.	Belt 6.	Total.
Early Rose	2.25	5.25	5.25	17	10	9.5	39.75
Rural No. 2	18	23	14	22.5	24	23	124.50
American Giant	2	1.5	2.50	3.5	3 25	5.25	18
	22 25	29.75	21.75	33	37.25	37.75	182.25
Plot II.							
Early Rose	....	4.5	10	....	10.5	12	37
Rural No. 2	....	22.5	21	....	22	23	88.5
American Giant	....	3	6.5	....	5	9	23.5
	....	30	37.5	....	37.5	44	149
Plot III.							
Early Rose	....	6	9	6.5	4.25	....	25.75
Rural No. 2	....	20	26.5	22.5	23	....	91.50
American Giant	....	2.5	4	5	3.5	....	15
	....	28.5	39.5	34	30.75	....	132.25
Plot IV.							
Early Rose	5	7.75	16.5	....	6.75	9.25	45.25
Rural No. 2	26	22.5	23	....	23.5	28	123
American Giant	6.5	4.5	13	....	4.75	4	32.75
	37.5	34.75	52.5	....	35.25	41.25	201

The yield of the various belts in each plot was quite uniform, it being larger in Plot IV. than elsewhere, but small in all portions of the series. The largest yield of all was from belt 3, Plot IV., where kainit and sulphur, each 200 pounds per acre, were added the present season; the second largest, in belt 6, Plot II., where Bordeaux has been added annually since 1894. The third best was from belt 6, Plot IV., where sulphur had been applied in 1895, followed closely by belt 3, Plot III., where kainit was applied in 1894 and 1896.

Fig. 10.
A Badly Scabbed Potato of (1) Early Rose, (2) Rural, No. 2, (3) American Giant.

Two of the limed belts were the lowest, and in the poorer half were the three belts to which sulphur had been added in 1896.

The amount of scab was determined in terms of per cent. by comparing the potatoes with those that had been preserved in formalin from the crop of 1896, as representing 100 per cent. of the disease. Figure 10 shows a badly-scabbed potato of each of the three varieties, (1) Early Rose, (2) Rural, (3) American Giant. The following table is constructed to show the scabbiness for each variety in each belt:

Plot I.	Belt 1.	Belt 2.	Belt 3.	Belt 4.	Belt 5.	Belt 6.	Average.
Early Rose	50	65	75	70	60	60	63.33
Rural No. 2	50	70	70	65	60	60	62.50
American Giant	50	55	70	50	65	55	57.50
Average	50	63	72	62	62	58	....
Plot II.							
Early Rose	45	55	75	...	75	65	63
Rural No. 2	55	60	65	...	70	60	62
American Giant	60	60	70	...	60	60	62
Average	53	58	68	...	68	62	....
Plot III.							
Early Rose	...	40	75	75	60	...	60
Rural No. 2	...	60	75	60	75	...	67.5
American Giant	...	50	75	75	70	...	67.5
Average	...	50	75	70	68	...	....
Plot IV.							
Early Rose	55	40	50	...	75	30	50
Rural No. 2	70	40	40	...	70	25	49
American Giant	55	45	55	...	70	5	46
Average	60	42	52	...	72	20	....

From the general averages a second table is deduced to show that there is very little difference in the percentage of scab among the three varieties, they being, as shown below, American Giant, 58; Early Rose, 59, and Rural No. 2, 60 per centum.

Totals.	Plot I.	Plot II.	Plot III.	Plot IV.	Average.
Early Rose	63.33	63	60	50	59
Rural No. 2	62.50	62	67.5	49	60
American Giant	57.50	62	67.5	46	58

It is seen that the lowest percentage of scab is in belt 6, Plot IV., where sulphur alone was applied in 1895 and none since then. The next is where corrosive sublimate was applied to the soil, and the third in two belts, the one bearing the largest amount of lime and the other the largest amount of sulphur. The average of the four sulphured belts, is less than 48 per cent. to 66 per cent. for the two checks. The kainit and sulphur belts averaged 60 per cent. and the limes 60 per cent. The organic acid (oxalic) and the mineral acid (sulphuric) had no desirable effect, the belt receiving the former giving 68 per cent. and the latter 60 per cent. of scab.

It will be seen that, so far as checking the scab was concerned, sulphur is the only substance that had any wholesome effect, and even with it there was no profitable diminution.

It should be remembered, in this connection, that the season of 1897 was remarkable for the excessive rainfall in July and August.

The summer of 1889 was a similarly wet one, followed by an unusual development of decay in the round or Irish potatoes, caused by *Phytophthora infestans* De By. The fine green and vigorous vines were quickly turned to a brown color and withered away, and upon digging the potatoes many of them were found to be rotten. Upon August 7th of that year, after visits had been made to the leading

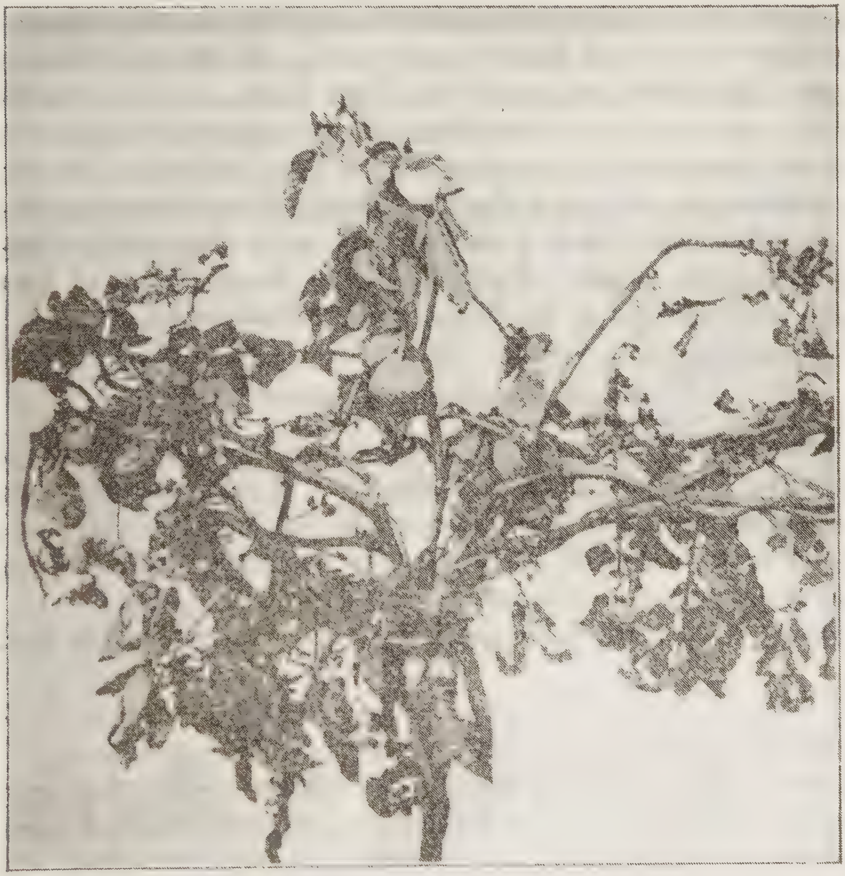

Fig. 11.
Appearance of Potato Vines when Attacked by Phytophthora, or Late Blight.

potato-growing regions of the State, a special bulletin was issued by the Station, giving the characteristics of the disease and the methods to be pursued. In all essentials, the contents of that bulletin applied with full force to the conditions of the potato fields for the past season. In fact, upon observing the appearance of the potato rot, copies of the bulletin of 1889 were sent to one hundred of the leading newspapers of the State on August 28th of the present year.

At the Experiment Area the disease was found upon all three varieties of potatoes, namely, "Early Rose," "Rural, No. 2," and "American Giant." The development of the fungus was more rapid upon the "Rural" than upon the other two sorts, and, by watching the growth of the disease from day to day, it was evident that there may be varietal differences in potatoes that render some sorts more susceptible to the disease than others. The "Rural," occupying the middle place in each belt, had larger and more vigorous vines than either of the other varieties and showed conspicuously the brown foliage and stems. The worst specimens of this Late Blight, as it is sometimes called, were found upon plants that were grown under the lath shading, but they came after the plants in the open had turned brown—in other words, the shaded plants were attacked later than the others.

As before stated, the cr p was harvested earlier than usual to escape the destructive fungus. Figure 11 shows the appearance of potato vines when attacked by the Phytophthora, or late blight.

Potato Experiments in Series VI.

Efforts to find a preventive of potato scab have also been made upon the first three plots of Series VI. A crop of Early Rose potatoes grown there in 1896 demonstrated that the soil of that portion of the experiment area was even more thoroughly infested by the scab germs than that of Series II., just considered.

As indicated in the accompanying plan, most of the belts in Series

	Belt 1.	2.	3.	4.	5.	6.
Plot I.	1896. Corrosive sublimate, 15 pounds	1897. Kerosene, 120 pounds.	1896. Corrosive sublimate, 60 pounds.	1897. Nothing.	1897. Carbon bi-sulphide, 120 pounds.	1896. Corrosive sublimate, 30 pounds.
Plot II.	1896. Sulphur, 240 pounds.	1897. Benzine, 120 pounds.	1896. Sulphur 480 pounds.	1897. Lower third shaded.	1897. Formalin. 120 pounds.	1896. Sulphur, 960 pounds.
Plot III.	1896. Kainit. 480 pounds.	1897. Nothing.	1896. Kainit, 960 pounds.	1897. Buckwheat, first crop.	1897. Fallow. first crop.	1896. Kainit, 720 pounds.

Fig. 12.

Plan of Potato Experiments in Series VI.

VI. received soil applications in the summer of 1896 or spring of 1897. The fungicides corrosive sublimate, sulphur and kainit were forked into the soil in August, 1896, along the lines where potatoes were to be grown. Upon April 13th of the present season, the series was planted to Early Rose potatoes, and immediately after the liquid fungicides, kerosene, carbon bi-sulphide, benzine and formalin, each diluted to thirty gallons, were applied to their respective belts, as shown in the above diagram. One-third of belt 4, Plot II., was shaded in the same manner as in Series II.

The plants grew about equally well upon all belts, they being a week later in blooming in the shade.

Upon August 4th the crop was harvested, and the table of results with number of plants, pounds of potatoes and percentages of scab is given herewith.

		Belt 1.	2.	3.	4.	5.	6.
Plot I.	Number of plants.......	59	58	49	58	60	59
	Weight of potatoes......	71.5 lbs.	62 lbs.	89.5 lbs.	52.5 lbs.	86.5 lbs.	98 lbs.
	Per cent. of scab.........	85	91	97	98	99	85
Plot II.	Number of plants.......	55	56	48	....	53	52
	Weight of potatoes......	66 lbs.	64 lbs.	33.5 lbs.	....	75.5 lbs.	83 lbs.
	Per cent. of scab.........	85	90	90	....	98	85
Plot III.	Number of plants.......	57	54	52	....	....	55
	Weight of potatoes......	71 lbs.	60 lbs.	48.5 lbs.	....	....	75 lbs.
	Per cent. of scab.........	94	97	99	....	....	91

It is seen that the lowest number of plants and yield of potatoes are in belt 3 of each plot, where the largest amount of the three substances, namely, corrosive sublimate, sulphur and kainit, were used. The potatoes of these belts, however, were no less scabby than when less amounts of the fungicides were used. In short, the scab was so universal that very little is to be said for any substance that was employed. The average scabbiness for the three corrosive sublimate belts is 89 per cent., for the three sulphur belts is 87 per cent. and for the kainit is 95 per cent. None of the liquids, namely, kerosene, bi-sulphide of carbon, benzine or formalin, proved in the least effective.

Plots I. and II., without any further soil treatment, were spaded belt by belt, and sown to beets for the purpose of studying the influ-

ence of the fungicides in the soil upon the development of the beet scab. This crop was harvested upon November 18th, and the results in terms of scabbiness of the roots are given in the following ratio: If the amount of scab upon the roots in the sulphured belts is placed at one, that of the beets where corrosive sublimate was added would be four, and for the checks five. In other words there was a very marked reduction in the amount of scab in the soil where sulphur had been added.

Plot III. was planted to a second crop of potatoes, but the seed, held over from the first planting, was poor and only a small percentage of the plants grew. In terms of scabbiness the results are as follows: Belt 1, 75 per cent.; belt 2, 65 per cent.; belt 3, 75 per cent.; belt 4, 65 per cent.; belt 5, 60 per cent.: belt 6, 65 per cent. This is a lower average of scab than in the first crop, that is, as 66.6 per cent. to 95 per cent. Kainit again does not show any signs of being a check upon the disease.

The lowest per cent. of scab was, as might be expected, upon the fallow land, and it was shown that the growth of buckwheat as a previous crop did not have any influence upon the amount of scab.

EXPERIMENTS WITH PEPPERS.

For the past three seasons peppers have been grown upon Plot I. of Series III. The "Bullnose" pepper, the only variety grown previous to 1897, not having been appreciably injured by disease, was supplemented the present season with nine other sorts, the list being as follows: "Long Red Cayenne," "Red Cluster," "Cardinal," "Henderson's County Fair," "Ruby King," "Bullnose," "Sweet Mountain," "Cherry Red," "Golden Dawn" and "Chili." Figure 13 shows a sample of each variety of fruit reduced to the same scale. Each belt contained six plants of each of the ten varieties, and the experiments with fungicides and shading were duplicates of those introduced in the tomato plot. The plants were set out June 4th and sprayed eight times upon the following dates: June 11th and 23d, July 8th and 24th, August 3d, 11th and 24th and September 9th and 22d.

In the above list of peppers there are some very decided contrasts as to size, shape and color of fruit, as there are also noticeable varia-

tions in foliage. It was thought not unlikely, therefore, that marked differences in relative susceptibility to blight might also appear. Disease was, however, almost wholly absent from this plot throughout the season, and all varieties appeared equally free from fungous attack. The experiment would seem to indicate that pepper plants

Fig. 13.
A Sample of each of the Ten Varieties of Peppers.

in general are too little infested by fungous enemies to warrant the application of fungicides.

The only contrast observed was that between the shaded and exposed plants in belt 6. The former were about a third smaller and their yield a third less than the same number of exposed plants elsewhere.

EXPERIMENTS WITH TOMATOES.

Tomatoes have been grown upon Plot II. of Series III. for the past four seasons. In 1897, instead of growing the Trophy tomato only, but one-seventh of the plants were of that sort; six other varieties being introduced, and a study of the comparative susceptibility of different commercial varieties was made a part of the experiment. The list consisted of the following well-known sorts: Early Ruby, Red Cherry, Golden Sunrise, Trophy, Ponderosa, Dwarf Champion and Peach. Some quite widely-different types of tomatoes are included in this list. The fruits, for example, ranged in size; that of the largest, represented by the Ponderosa, a single fruit of which often weighs one pound or more; the medium, represented by the Early Ruby, Golden Sunrise, Trophy and Dwarf Champion, down to the one-ounce fruits of the Peach, while those of the Cherry weighed less than half an ounce each. As to habit of growth, some of the varieties are inclined to be erect, while others are prostrate. Figure 14 shows the seven varieties in the order above named, from 1 to 7, with a sectional view of each in the lower row.

The first ripe fruits were gathered from the Cherry, the Peach and Dwarf Champion varieties about the middle of July, and not until the middle of August from the Ponderosa.

The Early Ruby formed the uppermost row across the plot, the other varieties following in the order named above.

Belts 1, 2, 4 and 5 were sprayed with soda-Bordeaux, hydrate, Bordeaux and potash-Bordeaux respectively. Belts 2 and 6 were unsprayed, and one row in the latter was shaded. The first spraying was May 22d, one week after the plants were set out, and between that date and October 4th, twelve applications were made at intervals of from seven to sixteen days. The reader's attention is briefly called at this point to the treatment which the two unsprayed belts, 5 and 6, received previous to the present season. In 1896 belt 2, which was the check in 1897, was sprayed with potash-Bordeaux, which prevented very effectually the development of disease. Belt 6 had piled upon it during the winter of 1895–6, all the old tomato plants of the previous season's crop, and being unsprayed in 1896 was severely blighted. Although belt 3 and the unshaded portion of belt 6 were both untreated the present season, there was a marked difference in the relative amount of blight in the two areas. Disease developed so

Fig. 14.

Seven Varieties of Tomatoes with a Sectional View of each in the Lower Row. (1) Early Ruby, (2) Cherry, (3) Golden Sunrise, (4) Trophy, (5) Ponderosa, (6) Dwarf Champion, (7) Peach

slowly in belt 3 that the yield of ripe fruits was affected but little, if at all. There was, however, a marked falling off in the number of green fruits collected from this belt at the season's close, which would indicate that disease had not begun to be at all serious there until after most of the crop had been harvested.

In belt 6, on the other hand, leaf-spotting was remarked upon the two unshaded rows much earlier and developed much more rapidly than in belt 3, and there was a very decided decrease in the amount of fruit produced. By the middle of September many of the plants were partially dead, and two entirely so.

The three Bordeauxed belts remained practically uninfested. Near the end of the season disease was somewhat noticeable upon the plants sprayed with hydrate, but scarcely enough, it was thought, to affect the yield.

Only one fungous disease, *Septoria Lycopersici* Speg., was found upon the tomatoes in the Experiment Area in 1897. Spotted fruits were comparatively rare, and there was no appreciable loss on this account. The few diseased fruits seemed to be attacked by *Glœosporium phomoides* Sacc.

A record was kept of the number and weight of ripe tomatoes, sound and spotted, gathered from each variety in each of the six belts, and on October 19th, after the plants had been slightly injured by frost, a final picking of all fruits of a marketable size, both ripe and green, was made. The total number and weight of ripe and green fruits produced by each variety in the six belts is presented in Figure 15. The yield of all seven varieties in each belt is also given. The product of the shaded row in belt 6 is presented in belt terms, and the two exposed rows in the same belt are likewise reduced.

			Belt 1.		Belt 2.	
			Sound.	Spotted.	Sound.	Spotted.
No. 1	Ripe	No. fruits	61	1	75	2
		Weight, ounces	303	1	414	8
	Green	No. fruits	14	....	29	....
		Weight, ounces	39	....	86	....
	Total	No. fruits	75	1	104	2
		Weight, ounces	342	1	500	8
No. 2	Ripe	No. fruits	1,048	1	1,991	....
		Weight, ounces	178	....	370	....
	Green	No. fruits	155	....	20	....
		Weight, ounces	21	....	1	....
	Total	No. fruits	1,203	1	2,011	....
		Weight, ounces	199	....	371	....
No. 3	Ripe	No. fruits	110	5	163	7
		Weight, ounces	588	19	717	26
	Green	No. fruits	30	1	15	4
		Weight, ounces	101	3	45	6
	Total	No. fruits	140	6	178	11
		Weight, ounces	689	22	762	32
No. 4	Ripe	No. fruits	80	4	96	4
		Weight, ounces	353	14	544	14
	Green	No. fruits	24	1	24	3
		Weight, ounces	80	2	97	6
	Total	No. fruits	104	5	120	7
		Weight, ounces	433	16	641	20
No. 5	Ripe	No. fruits	57	....	56	3
		Weight, ounces	563	....	597	27
	Green	No. fruits	7	1	30	2
		Weight, ounces	45	5	166	4
	Total	No. fruits	64	1	86	5
		Weight, ounces	608	5	763	31
No. 6	Ripe	No. fruits	78	4	128	4
		Weight, ounces	280	9	465	14
	Green	No. fruits	23	....	17	....
		Weight, ounces	64	....	45	....
	Total	No. fruits	101	4	145	4
		Weight, ounces	344	9	510	14
No. 7	Ripe	No. fruits	370	19	514	39
		Weight, ounces	495	20	700	40
	Green	No. fruits	53	2	65	8
		Weight, ounces	64	2	70	10
	Total	No. fruits	423	21	579	47
		Weight, ounces	559	22	770	50
Grand Total		No. fruits	2,110	39	3,223	76
		Weight, ounces	3,174	75	4,317	155

Fig. 15.

Results of the Tomato Experiments for each of the seven varieties.

Belt 3.		Belt 4.		Belt 5.		Exposed.		Shaded.	
Sound.	Spotted.	Sound.	Spotted.	Sound.	Spotted.	Sound.	Spotted.	Sound.	Spotted.
91	1	109	1	58	10	81	...	63	...
42	3	598	1	32	42	402	...	86	...
23	...	100	...	91	...	50	...	36	...
69	...	256	...	208	...	132	...	90	...
114	1	209	1	149	10	131	...	99	...
497	3	854	1	528	42	534	...	450	...
2,287	3	2,378	3	1,978	2	1,545	...	765	...
404	...	395	...	385	...	267	...	123	...
51	...	200	...	220	...	84	...	159	...
6	...	87	...	27	...	11	...	18	...
2,338	3	2,578	3	2,198	2	1,629	...	924	...
410	...	482	...	362	...	278	...	141	...
183	4	194	6	174	5	96	2	123	3
850	4	863	19	818	13	402	9	387	9
39	2	80	...	113	...	11	...	12	...
137	2	237	...	328	...	29	...	27	...
222	6	274	6	287	5	107	2	135	3
987	6	1,100	19	1,146	13	431	9	414	9
150	1	190	1	210	3	126	...	72	6
654	2	786	3	927	15	426	...	387	27
24	...	79	2	84	2	29	...	36	...
66	...	206	2	268	3	87	...	45	...
174	1	269	3	294	5	155	1	108	6
720	2	992	5	1,195	18	513	...	432	27
65	5	84	4	53	2	50	2	33	3
716	20	882	21	585	14	392	11	177	6
25	1	32	1	21	...	8	...	...	...
87	2	150	4	96	...	24	...	...	...
90	6	116	5	74	2	58	2	33	3
803	22	1,032	25	681	14	450	11	177	6
105	...	93	1	113	4	89	...	63	...
375	...	430	3	418	9	254	...	216	...
...	...	32	...	32	1	6	...	...	...
...	...	108	...	106	2	6	...	...	...
105	...	125	1	145	6	95	...	63	...
375	...	538	3	524	11	260	...	168	...
490	43	536	31	815	19	336	14	573	6
638	44	723	35	1,044	21	369	11	654	6
40	8	46	8	137	10	23	...	105	...
42	10	49	10	148	12	24	...	126	...
530	51	582	38	952	29	359	14	678	6
680	54	772	45	1,192	33	393	11	780	6
3,573	68	4,153	57	4,099	58	2,534	18	2,040	18
4,464	87	5,715	98	5,578	181	2,825	81	2,610	48

From the above table of results, it will be seen that in belts 1 and 2, sprayed with soda-Bordeaux and hydrate respectively, there was a marked falling off in the amount of fruit produced, that of the

Fig. 16.
Tomato Stems Affected with Blight.

hydrate belt being lower for most varieties than the check, and a somewhat lower yield still was obtained from the soda-Bordeauxed belt. A satisfactory explanation for the negative results in these two belts cannot as yet be given. Both fungicides burned the foliage

somewhat, but scarcely enough, it would seem, to do serious harm. Very little leaf-spot developed upon the soda-Bordeauxed plants, while those sprayed with hydrate were less infested than the check plants in the belt adjoining. Soda-Bordeaux was applied to belt 1 in 1896 with very favorable results, there being but little blight, while the yield of fruit was fully up to the average. This variation in the first two belts may be explained by another season's experiments, but in presenting the results of this year's work with tomatoes it seems best to confine our comparisons to belts 3, 4, 5 and 6, the returns from which, whether favorable or unfavorable, can be attributed with some degree of certainty to a definite cause.

Compared with the Bordeauxed belt, the yield of ripe fruits in the check is seen to have been lower for all varieties, while in case of four varieties in the potash-Bordeauxed belt the yield was somewhat lower than in the check. The amount of green tomatoes gathered from the check was, however, very much lighter than that obtained from the Bordeauxed or potash-Bordeauxed belts, there being for most varieties from twice to three times the weight of green fruits gathered from each of these two sprayed belts than from the check. This marked falling off in the number of late fruits produced by the check indicates how much more seriously the plants in that belt were infested by disease toward the close of the season. Figure 16 shows the appearance of badly-blighted tomato stems and leaves.

For reasons already given, the two exposed rows in belt 6 were more truly check rows than those in belt 3. From the table of results it will be seen that the yield from the above two exposed rows reduced to belt terms was, with the exception of the shaded row in the same belt, the lowest in the plot. It was less by about one-third than that of belt 3, unsprayed, and only about one-half that of the Bordeauxed and potash-Bordeauxed belts.

The least productive portion of the plot was the shaded row in belt 6. Reduced to belt terms, the yield of the plants so treated is seen to have been somewhat less than that of the exposed rows in the same belt. But while the latter were so severely injured by blight, the shaded row beside them suffered on this account comparatively little, it being less infested than were the unsprayed plants in the check belt.

EXPERIMENTS WITH LIMA BEANS.

In 1896, dwarf lima beans were planted in Plot IV., Series III., as a second crop and in the alternate rows where wax beans had been harvested early, the other rows being left for seed. No crop was expected from this late planting, but tests were made with the various fungicides in use that year.

During the present season the same plot has been in dwarf lima beans, the planting and treatment being as follows: Three varieties were selected, namely, the Burpee, Dreer and Henderson dwarf limas as shown in Figure 17, and a double row of each was planted upon April 29th in each of the six belts. The treatment consisted in spraying the plants in belt 1 with soda-Bordeaux, belt 2 with hydrate, belt 4 with Bordeaux, and belt 5 with potash-Bordeaux. Belt 3 was reserved as a check and belt 6 carried an experiment in shading.

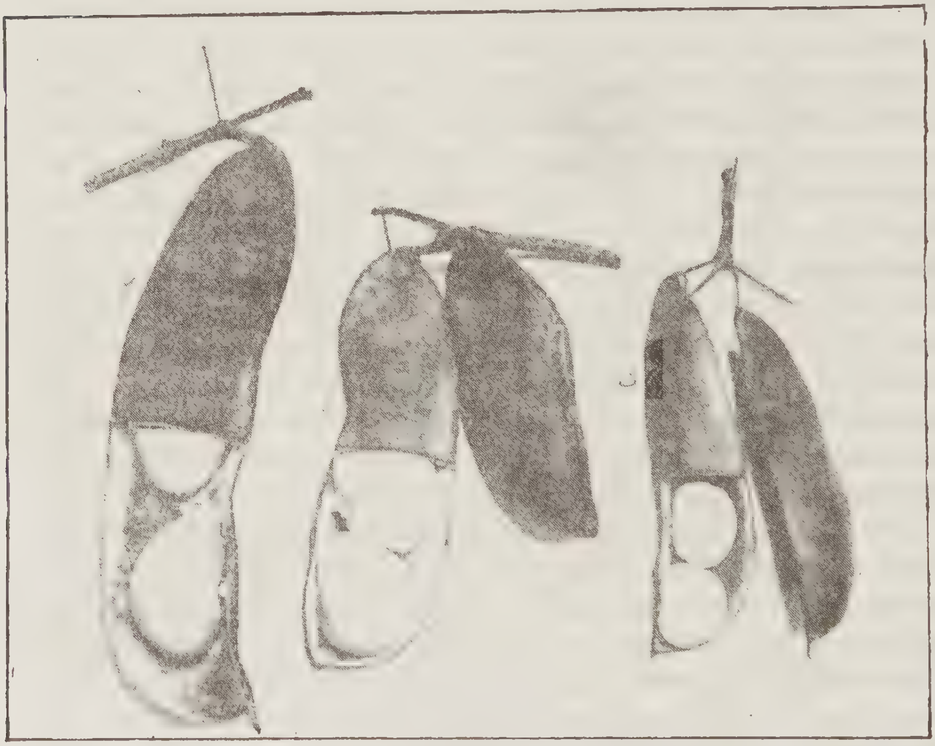

Fig. 17.
A Sample of (1) Burpee, (2) Dreer and (3) Henderson Dwarf Lima Beans.

Nine sprayings were given the plants and upon the following dates: May 22d, June 11th and 23d, July 7th and 23d, August 2d, 11th and 24th and September 8th.

The crop was harvested upon September 27th and 28th, but, as the Henderson comes into bearing much earlier than Burpee and Dreer, two pickings of ripe pods were made from this variety only previous to the above dates, namely, upon August 21st and September 11th.

Burpee.	Soda.	Hydrate.	Check.	Bordeaux.	Potash.	Total.
No of plants	101	83	94	78	84	440
Total weight	51	51.5	56.5	56.75	49.75	265.5
Sound pods	20.5	20	21	21	17.5	99
Spotted pods	.75	3.5	1.75	1.75	1.25	9
Dry pods	.75	2	2.75	1.5	1.5	8.5
Dreer.						
No. of plants	113	93	98	107	109	510
Total weight	36	22.25	24	39	33.5	154.75
Sound pods	11	6.25	6	11	11	45.25
Spotted pods	.75	.75	.5	.5	.5	.3
Dry pods	1.5	2	2.5	2	2	10
Henderson.						
No. of plants	84	62	56	84	63	349
Total weight	16.75	13.25	13.50	11.75	11.25	66.80
Sound pods	11.25	7.75	7.75	5.75	6.50	39
Spotted pods	...	....	....	....	...	....
Dry pods	9.50	5.50	5.75	3.75	3.75	28.25
Total No. of plants	298	238	238	269	256	....
Total weights	103.75	86.50	94	107.50	94	....

From the totals at the right hand of the table, it is seen that the stand of plants was best with the Dreer and poorest with the Henderson. The Burpee is much the heavier variety—the total weight of pods being for it 99 pounds, 45 for Dreer and 39 for Henderson. Two separate pounds of pods of each variety were shelled and the seeds weighed, and all sorts agreed almost exactly in having one-half their weight of beans and the other half empty pods. Upon this basis, the ratio of productiveness is as 20, 9 and 8, respectively, for the three varieties.

It is seen at once that there is very little blight of any kind. Of the total of twelve pounds of diseased pods, nine were in Burpee and the other three pounds in the Dreer sort. In time of maturing there is no marked difference between the Burpee and Dreer, while the Henderson begins to furnish pods for picking at an early date, and a large percentage were matured at the time of the termination of the

experiment. This variety, while its yield is not large, has its picking season extended over a long period.

The total weights at the bottom of the table show nothing for or against the treatment, as it has been shown that there was very little blight in any part of the plot. The check and the hydrate belts chanced to have the smallest total number of plants, soda-Bordeaux and Bordeaux having the larger number of plants. The total weights vary according to the total numbers of plants, and no conclusions can be drawn from the spraying experiment.

As it is the purpose to continue the study already begun with lima beans, the following items have been gathered as to the history of the three varieties in hand:

Origin of Three Dwarf Limas.

The Burpee.—From Professor Bailey's bulletin * it is gathered that the Burpee originated with Mr. Asa Palmer, of Kennet Square, Pa., who, after growing it for some years, placed his stock in the hands of Mr. Burpee, who introduced it to the public in 1890 as the Burpee Bush Lima. The origin of the variety dates back to 1883, when Mr. Palmer, after his pole beans had been destroyed by cut-worms, found one plant had re-rooted, remained dwarfed and bore three pods of one seed each. Two of these three seeds the next season produced dwarfed plants, and from these the Burpee was introduced six years later. The Burpee Dwarf Lima is an accidental dwarf from the true pole lima bean (*Phaseolus lunatus var. Macrocarpus* Benth.)

The Dreer.—This bush lima originated from the Challenger Pole Bean by selection of dwarf forms which Mr. J. W. Kumerle found growing in his field at Newark, N. J. The stock was introduced by both Thorburn and Dreer in 1889, but is now generally known in the trade under the name of Dreer's Bush Lima. It is of the same blood as the Burpee, namely, *Phaseolus lunatus var. Macrocarpus* Benth.

The Henderson.—This dwarf lima, as Professor Bailey writes, "was picked up twenty or more years ago by a negro who found it growing along a roadside in Virginia. It was afterwards grown in various gardens, and about 1885 it fell into the hands of a seedsman

* The Dwarf Lima Beans, Bulletin 87, Cornell University Agricultural Experiment Station, April, 1895.

in Richmond. Henderson purchased the stock of it in 1887, grew it in 1888 and offered it to the general public in 1889." This is of the Sieva type and therefore of the species *Phaseolus lunatus* Linn.

All three varieties were introduced in two years.

Description of Lima Beans.

The Burpee—Stem eighteen to twenty-two inches high, somewhat inclined to "run," from a strong root system forming a group of branches in the axles of the cotyledons and all other of the first half-dozen leaves, thus giving the plant a very irregular habit of growth and no tendency to keep branches in a single plane. The leaflets, three to five inches long, are green with entire margins; upper leaflet broadly lanceolate, nearly triangular, and in the plane of the long (six to seven inches) slender petiole, lower leaflets broadly lobed upon the lower half and hang with blade at right angles to the petiolule. The pair of unifoliate leaves very large and conspicuously mottled. Inflorescences vary greatly in size from one inch with the smallest lowermost ones to six or more inches in the terminal flower stalk that usually rises well above the surrounding foliage, and bears widely separated blossoms; flowers seven to nine lines long, upon peduncles six lines long, with white-winged petals; pods four to five inches long, 1 to 1.35 inch broad, usually broadly scymitar-shaped and coiled, somewhat tapering at upper end, ventral margin slightly grooved, not strongly swollen at seeds. Seeds two to four, three-fourths to one inch long, flat, nearly white with veins.

The Dreer.—Stem ten to fifteen inches high, not inclined to "run," from a widely branching root system, forming stout branches uniformly in the axles of the trifoliate leaves, the lowermost bearing leaves with flower clusters in their axles, while the upper (five or six) leaves of the main stem bear axillary inflorescences only. There is a strong tendency for the branches to remain in the same plane, the lower petioles bending sidewise to accommodate their leaflets. The leaflets are three to five inches long, light, somewhat ashy-green in color, and green-veined, with slightly wavy margins, and the upper leaflet broadly lanceolate, parallel with the stiff upright petiolule, the lateral ones larger and broadly lobed upon the lower half and hang with blade at right-angles with the petiole. The pair of unifoliate leaves large and conspicuously mottled. Inflorescences twenty to twenty-

five, small, few (six to ten), flowers scarcely showing above the foliage; the lowermost blossoms maturing the fruit. The flowers six to eight lines long upon short, stiff peduncles four to five lines long, wings white and reflexed. Pods whitening at maturity three to four inches long, 1.2 to 1.45 inches broad, nearly straight, blunt at both ends, ventral margin deeply grooved, strongly swollen at seeds. Seeds two to three, five-eighths to three-quarters inch long, oval, greenish-white.

The Henderson.—Stem twelve to sixteen inches high, somewhat inclined to "run," from a wide-spreading root system, forming feeble branches in the axles of the cotyledons, but good fruit-bearing ones from the axles of the first pair of leaves, giving the whole plant a well-balanced form. In the axles of the first three or four trifoliate leaves, clusters of branches are produced bearing leaves and inflorescences in their axles. The leaflets two and a half to three and a half inches long are deep glossy-green, with slightly wavy margins, and main veins white upon the under side, the upper leaflet broadly lanceolate and trowel-shaped in the coil of leaf and position of blade and petiolule. The lower leaflets broadly lobed upon the lower side and tilted upward so that the leaflets hang at right-angles to the petiole. The pair of unifoliate leaves medium sized and scarcely mottled. Inflorescences are short and few flowered in the lower axles, but much prolonged in the upper part of the plant and extend conspicuously above the foliage. Flowers small, three to four lines long and with a greenish-yellow appearance as seen in the field. Pods browning at maturity two and a half to three inches long, one-half to seven-eighths inch broad, blunt at both ends with sharp tip at base, broadly scymitar shaped, ventral margin grooved, not swollen at seeds. Seeds two to three, one-half to five-eighths inch long, flattish, white.

The three varieties are very distinct in size and form of seed and of seedlings. The Burpee is the largest from the start, the Dreer next and the Henderson smallest, and the latter in germination was about two days later in showing above ground. The Burpee was the first to bloom, the Dreer one week later and Henderson about midway of the two.

The fungicides marked the foliage somewhat, as observed after the third spraying upon the oldest leaves. With soda-Bordeaux the Burpee shows the injury more than any of the other varieties. A

slight injury was shown in the hydrate belt as also where Bordeaux and potash-Bordeaux were used. The Henderson was least affected in all the sprayed belts. The appearance of the injury is that of "bronzing" and a distinct darkening of the main veins.

Later on in the season the same fungicides did no harm, which fact leads to the opinion that the earliest leaves are much more tender than those produced later, and that it is likely that it would be well to use a half-strength solution for the first two sprayings.

While there were no indications of good effects of spraying in fruit product, it was, nevertheless, observed that the foliage of the treated belts showed much less blight than elsewhere. The ratio of this blighting upon the three varieties was as follows: Burpee, 5; Dreer, 5, and Henderson, 1.

In belt 6 one-third of the area was shaded, and here the first planting failed almost entirely, only three plants showing above ground seventeen days after the seeds were planted. Upon June 22d the shaded ground was replanted and an extra row of each variety was put in in the exposed portion of the belt. Upon July 5th the weather being extremely hot and dry, it was noted that the plants in the shade were all up and the first leaves well developed, but only an occasional plant showed in the open ground. They, however, came through quite suddenly after the heavy rains of July 12th–14th.

The failure of the beans to grow under the shade is a good illustration of the effect of temperature of soil upon germination, and it is not unlikely that the decay of lima beans in the soil is due in large part to being placed in soil not yet warm enough. Quite different results were obtained in the second planting, for there the shade not only furnished enough heat, but sufficient moisture for germination, while the latter was lacking in the open, where the seeds remained below ground until a soaking rain had fallen.

Notes Upon Mildew of Lima Beans.

Complaints have been so serious concerning the mildew of lima beans that a visit was made in October to the region where the attack seemed to be the worst, namely in Bergen county, and in the vicinity of Saddle River, Ridgewood and Paramus. Here the pole limas were so badly attacked that few or no pods were picked from some of the

fields. The mildew was worse with plants growing upon the rich low land and where the same crop had been upon the ground the previous year. Figure 18 shows two badly mildewed pods.

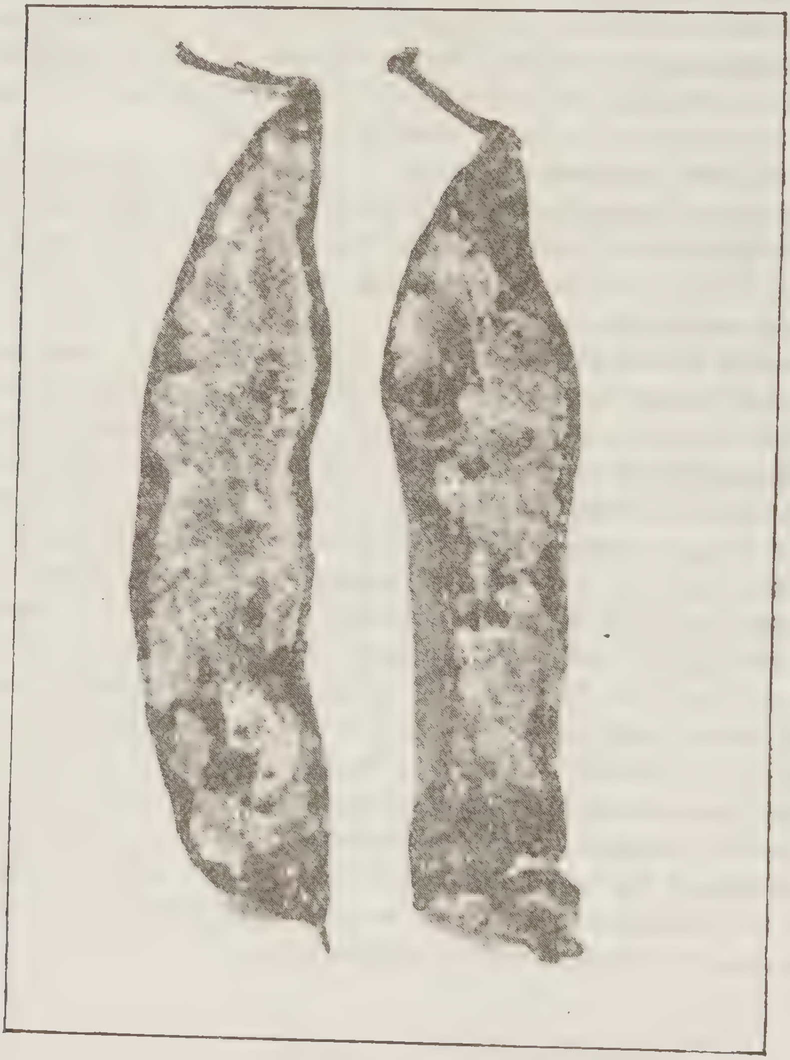

Fig. 18.

Two Badly Mildewed Lima Beans.

Not only the young pods, but the whole flower cluster was destroyed, and the dead tips of these stood up above the surrounding leaves of

the hill of plants. Some of these blighted tips are shown in Figure 19. One grower told me that late beans from the second planting were the most diseased and proved worthless.

Fig. 19.

The Badly Mildewed Tips of Lima Bean Vines.

In seasons like the present one it would seem best for lima beans to be put upon high ground, planted as early as possible and not upon old bean land.

EXPERIMENTS WITH ONIONS.

For several years the Botanist of the Station has been upon the watch for the genuine smut of the onion due to the fungus *Urocystis cepulæ* Fr., but not until the present season has it been detected in New Jersey. A large grower of onions for seed and for sets has had more or less trouble with his onion crops and has sent from time to time for a few years past samples that he thought might be infested with the genuine smut. The first specimens affected with *Urocystis cepulæ* Fr. were sent by him upon May 15th of the present year, and so abundant was the smut and so discouraging the report that a visit was made to the onion fields upon May 29th for observations and further information. There were four fields sown for sets, one for large onions, one field set for large onions and several set for seed. One field that had been in onions for thirteen years was spotted and yellow, and to the ordinary observer gave promise of a poor crop. Upon examining the plants upon the half of the field sown to white onions fully one-third of the seedlings were found to be smutted. The adjoining half was occupied with a yellow onion, and here the smut was much less, not more than an eighth being affected. It was found upon questioning the owner that he grew his own seed and that the two halves of this field were in every way the same, except that one was sown with the white onion seed and the other with the yellow.

At the lower end of this onion field was an acre or so that had not been previously in onions, and, while everything else was in common, it was easy to see the line between the old and new ground, in the better stand and larger size of onions upon the land bearing onions for the first time. Smutted plants were, however, found upon this new land, and the greatest percentage upon a portion that was low enough to receive the wash of rains from the old land somewhat above it. Along the end farthest from the old onion land there was but little of the smut, and almost none at all at the highest points along this side.

From the observations made upon this field, it would seem that there are marked differences in the susceptibility of varieties to the smut, the tender, and therefore highly-prized, white sort being much more inclined to smut than the yellow sort.

There is also an illustration found of the way in which the smut germs may spread from one land to another by washing, for it is as-

sumed that the old land had in previous year or years at least a small amount of the smut, but not in quantity to attract attention.

The above view is strengthened by the fact that an examination of other new fields sown with seed from the same lot of seed onions showed no smut, which leads to the opinion that the disease was not communicated by the seed, but came from germs retained in the soil.

An examination was made of the seed onions, and in no case was any sign of smut to be found in either those of one or two years' standing. Sets placed out for large onions were likewise not smutted, but an old onion field that was sown with seed for large onions showed a large percentage of smut, so large in fact as to discourage the grower in the thought of maintaining the crop.

Seeds, sets and plants for seed for the experiment upon the home grounds had been previously obtained from this same grower.

Plot I., Series IV., was devoted to onions during the present season. In belts 1, 2 and 3 onions were set for seed, while in belts 4, 5 and 6 the three rows of sets alternated with as many rows sown with onion seed. Belts 1 and 4 had sulphur added at the rate of 240 pounds per acre; belts 3 and 6, kainit, 240 pounds per acre, while belts 2 and 5 received no soil treatment. A lath shade was placed over the lower portion of belts 3 and 4, thus covering a small portion of the onion plants grown for seed, and those from sets and from seed. The setting and sowing were done upon April 22d.

The sprayings were made lengthwise of the plot, so that each of the four fungicides had an equal share of the area with soil treatments. Six sprayings were made upon the following dates: May 22d, June 2d, 11th and 23d, July 7th and 23d. Very little blight of any sort appeared upon the seed onions, and none elsewhere; but all were badly eaten by insect enemies, the ravages of which were not apparently checked by any of the fungicides. No smut was met with anywhere, and the results of this experiment amount to nothing unless it be the fact that the onion is not a plant upon which fungicides readily adhere. Even in the shaded portion there was almost no difference in the growth of the plants.

Box Experiments with Onions.

A series of box experiments was carried out with onions, a quantity of fresh-smutted onions having been secured for the purpose. The boxes used were about eighteen inches square and holding fifty pounds

of soil. The following is the schedule of treatments, the seed in all cases being smeared with smut.

1. Seed sown in untreated soil.
2. Seed soaked in hot water (135° F.) for fifteen minutes.
3. Seed soaked in corrosive sublimate, one to one thousand, one hour.
4. Seed rolled in sulphur.
5. Seed in soil bearing one to one thousand of corrosive sublimate.
6. Seed in soil bearing one to four hundred of sulphur.
7. Seedling onions, free from smut, transplanted into smutted soil.
8. Seedling onions, free from smut, transplanted into clean soil.

The seed was sown June 26th, and the plants came up fairly well in all boxes except the one where the seed had been treated with hot water, and there failure was complete.

While there were differences in the number and vigor of the plants in the several boxes, they all agreed in not contracting the smut in any instance, and therefore the experiment yields no positive results.

EXPERIMENTS WITH SPINACH.

The introduction of spinach upon the Experiment Area was in Plot II., Series IV., where, upon April 20th, each of the six belts was alike sown to seven varieties, as follows: (1) Norfolk Savory-leaved, (2) Victoria, (3) Thick-leaved, (4) Round-leaved, (5) New Zealand, (6) Prickly, (7) Round-leaved Viroflay. One-third of belt 6 was shaded, and belts 1, 2, 4 and 5 were sprayed with soda-Bordeaux, hydrate, Bordeaux and potash-Bordeaux, respectively, upon the following dates: May 22d, 29th, June 11th and 23d.

There was a good stand of all varieties, except the New Zealand, of which only a half-dozen plants grew, but eventually occupied a good share of the space for this variety.

Upon the same date, and in the same manner, belt 6, Plot III., Series 0, was also sown to spinach. This was in the beet series, the purpose being to determine whether the blights of the beet would appear upon the spinach, the two crop-plants being very closely related botanically.

The trouble, often complained of by spinach growers, appeared early in all the belts, and did not seem to be influenced by the fungicides. The cause of the loss of green color and the final dwarfing of the diseased plants is not yet determined, and all that was hoped for

during the first year was the introduction of the new crop to the Experiment Area, and the development of the troubles for future investigation upon the same land. The crop was therefore allowed to stand and re-seed itself, so that a partial second crop of volunteer plants was produced.

It was a matter for remark that the spinach under the shade made larger plants and remained green longer than those fully exposed to the sun, and it seems probable that this crop can be grown with profit throughout the season where some protection, as a partial shade, is provided.

In the belt in the beet series upon July 17th many of the leaves of the spinach showed small circular spots similar to those that were beginning to appear upon the foliage of the beets in the adjoining belts. Upon examination these were found due to a *Cercospora*.

Some years previously the writer made a canvass of the diseases of the spinach, the results of which were published in a bulletin* from the Station. During this investigation no *Cercospora* was found, but later in the year and after the bulletin was issued another enemy to the spinach was found upon a truck farm, where it was doing much damage and where the loss was estimated at 400 barrels. This find was recorded in the report of this department for 1889, page 355.

The point of interest is that there are no differences between this *Cercospora* and *C. beticola* Sacc. upon the beet and that the exceedingly favorable conditions for inoculation had proved successful upon what seems to be a new host.

There are gross differences in the appearance of the spots that are readily accounted for by the differences in the hosts. Thus, in the beet the spots are often outlined by a pink or reddish border entirely absent in the spinach. This coloration, however, in the beet is confined to the red sorts that have a tendency to develop a reddish color whenever and wherever an injury occurs. There is also some difference in the length of the conidial hyphæ, possibly due to structural differences of the epidermis of the host. But when the spores are measured they are found, while variable, as they always are in the *Cercospora beticola* Sacc., to be within the limits of the species.

The spinach belt in the beet series was sown for the second crop upon August 17th, and a good stand was produced that will be left upon the ground over winter.

* "Some Fungous Diseases of Spinach," Bulletin No. 70, N. J. Experiment Station, July 26th, 1890.

EXPERIMENTS WITH EGG-PLANTS.

Plot III., Series IV., was in egg-plants the present season for the third successive year,* four varieties being used in equal numbers as follows: (1) Early Long Purple, (2) New York Improved, (3) Improved New York Spineless, (4) Black Pekin. A fruit of each sort is shown in Figure 20. The first variety occupied the uppermost row, running lengthwise of the plot, and the other three sorts followed in the order given. There were three of these sets of four rows in the whole plot, so that Early Long Purple occupied rows 1, 5 and 9,

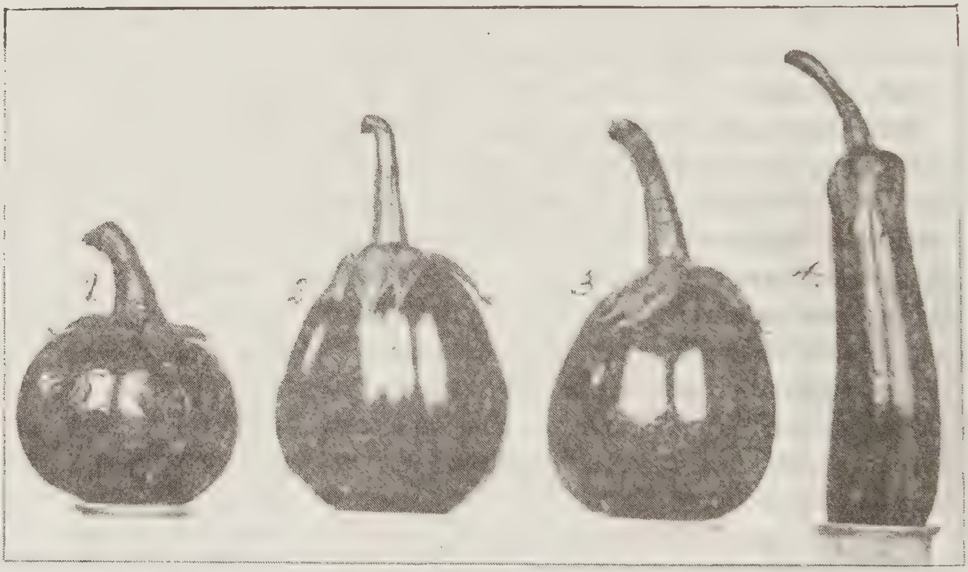

Fig. 20.

Four Varieties of Egg-plants—(1) Black Pekin, (2) N. Y. Spineless, (3) N. Y. Improved, (4) Early Long Purple.

running lengthwise of the plot, and therefore crossing the belt rows at right angles. Belts 1, 2, 4 and 5 were sprayed ten times with soda-Bordeaux, hydrate, Bordeaux and potash-Bordeaux respectively, and upon the following dates: June 12th, 24th, July 8th, 24th, August 3d, 11th, 24th, September 8th, 21st, and October 4th. The plants were grown from seed sown in the greenhouse April 6th, transplanted May 13th, and set out upon June 4th. Shade was provided for four plants, one of each variety, in belt 6.

*For records of previous crops see report for 1895, pages 299-303, and for 1896, pages 337-340.

The plants in all belts grew fairly well, showing but little difference until early in September, when fruits failed to mature and the plants sickened throughout the plot.

The leaf-spot fungus (*Phyllosticta hortorum* Speg.) was upon the foliage generally, and nearly all the fruits were destroyed by it before more than half grown. Upon October 29th the harvest was made by belts and varieties, and the results are given below:

	Belt 1.		2.		3.		4.		5.		6.		Total.	
	Good.	Rotten.	Good.	Rotten.	Good.	Rotten.	Good.	Rotten.	Good.	Rotten.	Good.	Rotten.	Good.	Rotten.
No. 1	2	12	5	24	1	14	0	14	1	19	0	6	9	91
No. 2	2	5	2	13	0	4	3	17	2	6	0	6	9	51
No. 3	2	3	1	8	0	4	4	6	4	8	0	3	11	32
No. 4	0	1	0	4	0	2	0	2	0	4	0	3	0	18
Totals	6	21	8	49	1	24	7	39	7	37	0	18	29	192

In total fruits the checks are below all others, and here there is only one sound fruit out of forty-three. There is but little difference in the effectiveness of the four fungicides, the hydrate and Bordeaux being a trifle better than the potash- and soda-Bordeaux. The shaded plants gave only two fruits and those were decayed.

An examination of the roots at the time of harvest showed that they were infested with nematode worms, and in some cases the galls were quite noticeable, a sample of which is shown in Figure 21.

Nematodes in ornamental plants have been considered at different times in the reports of this department, as of bouvardia, coleus, chrysanthemum, lantana, oats and rose in 1890, ferns, moonflower, pelargonium, salvia and zinnea in 1891, ficus, rose and violet in 1892 and violet in 1894. In a large number of the above cases the worms were found in the foliage, where they caused a browning of the tissue and the ruin of the infested leaves. Notable exceptions to the foliar nematodes are those producing root galls upon the rose and violet, where these parasites do a large amount of harm.

In the Southern States the nematodes are much more abundant than with us, the cold of winter being destructive to them at the North.

Professor G. F. Atkinson,* then at the Alabama Experiment

* "Nematode Root Galls," Bulletin No. 9, Alabama Experiment Station, December, 1889.

Station, made a study of the nematodes and listed thirty-six plants that were attacked as observed by him in Alabama. Among these are the following truck plants in the order given: Potatoes, egg-plants, tomato, okra, bean, watermelon, citron, beet, cabbage, turnip, parsnip, lettuce and salsify. The Northern growers of these plants may be thankful that their crops are generally uninjured by these worms, the scientific name of which, according to Professor Atkinson, is *Heteroderma radicicola* Mull.

Fig. 21.

Roots of Egg-plant Affected with Root Galls.

Should the crops of the colder regions become infested seriously the land might be laid down to grass, or ridging for more thorough exposure to the elements in winter might prove effective. As yet, our greatest injury is done to tender plants grown indoors, as roses and violets.

There is but little to be written upon the susceptibility of varieties, for all were generally attacked. The Early Long Purple bears a small fruit, and naturally exceeds all others in total numbers, but the percentage of rotten ones is also great, exceeded only by the Black Pekin, which had but few fruits that cracked badly and were all decayed. The New York Improved surpassed the Improved New York Spineless in total yield, but the latter had the largest number of sound fruits. So far as this single test goes the No. 3 is the best variety when the blight is considered.

EXPERIMENTS WITH LETTUCE.

Plot IV., Series IV., was sown to lettuce for the first time upon April 8th. The varieties used and the order of the rows for each belt, beginning at the left hand of the plot, are as follows: (1) Asparagus, (2) Salamander, (3) Improved Hansen, (4) Wonderful, (5) Summer Drumhead, (6) Trianon Self-folding, (7) Big Boston. Belts 1, 2, 4 and 5 were sprayed ten times with soda-Bordeaux, hydrate, Bordeaux and potash-Bordeaux, respectively, upon the following dates: May 22d, 29th, June 11th, 23d, July 7th, 23d, August 2d, 12th, 24th, and September 8th. One-third of belt 6 was shaded.

In the early sprayings all the fungicides injured the plants to some extent; those by the soda-Bordeaux being the most, potash-Bordeaux next, hydrate third, and Bordeaux least. Some varieties were more sensitive than others, the Salamander (row 2 in each belt) being the worst, even standard-strength Bordeaux scalding this sort to some extent. The Improved Hanson was the next most susceptible to injury.

There was very little blight, *Septoria Lactucæ* Pass., upon the plants until they had passed blooming, except in belt 6, where a second crop was sown July 8th, where in the exposed portion the leaves of quite small plants blighted badly.

The plants upon the first five belts were permitted to remain upon the ground to go to seed and self-seed the plot, that the germs of the diseases of the lettuce might accumulate in the soil for future experiments with the crop.

No estimate was made of the amount of blight either upon the belts as such, to test the relative value of the four fungicides used, or of the susceptibility of the different varieties, there being so little of the disease at the time when the plants were of edible size.

The following notes were, however, made upon belt 6, just previous to preparing the ground for the second crop. Under the shade the stand of plants was as good as elsewhere, the thinning not having been done quite thoroughly enough anywhere for the best production of good heads. The color of the lettuce in the shade was a somewhat lighter green than in the full sun, and the plants were a trifle taller. The seed-stalks when formed were less densely leaved under the laths than elsewhere.

There was scarcely a dead leaf among the shaded plants, while those in the full sun had such upon nearly every plant. In short, the plants were slightly drawn, the foliage less dense and free from all that blotching that is variously styled sun-scald, blight, etc.

Row 1. "Asparagus." This is a new variety of the cos type, and at time of pulling the plants they were nearly three feet tall and had never shown any tendency to produce head or edible substance. The plants were a trifle more forward in the sun than the shade, for in the former they were coming into bloom, while in the latter only buds were found. The lower leaves of great length were somewhat larger in the shade than the sun.

Row 2. "Salamander." These plants were much fresher-looking and of a lighter green than those in the sun. The stems, about eighteen inches high, were somewhat drawn in the shade.

Row 3. "Improved Hanson." These plants were without seed stalks, otherwise as in No. 2.

Row 4. "Wonderful." This is a new sort, and a superior lettuce for large, firm heads of fine quality. Same conditions obtain here as with No. 3.

Row 5. "Summer Drumhead." Same as No. 2.

Row 6. "Trianon Self-folding." Same as No. 2.

Row 7. "Big Boston." Smallest of all the sorts. No seed stalks formed. The characteristic pink of plants in sun not present in the shade.

In the second crop, only "Salamander," "Wonderful" and "Trianon Self-folding" were sown, two rows of each. Rains continued for weeks after this sowing, and the difference in conditions between shaded and exposed areas was much less than expected. The plants came up about equally quick and well in all parts of the belt, but as soon as dry, hot weather came the shaded plants took the lead, and upon August 21st the record shows that the exposed plants

Fig. 22.

A Sample Pod of each of the Six Varieties of Beans. (1) Green Flageolet, (2) Currie's Rust-Proof, (3) Early Mohawk, (4) Improved Golden Wax, (5) Early Refugee, (6) Saddle-Back Wax.

NIV

were only two-thirds the size of those under the shade. The quality was also found superior in the shade, and the test suggests that lettuce can be grown successfully in midsummer by employing partial shade.

EXPERIMENTS WITH BEANS.

During 1897, Plot I., Series V., has been in beans for the seventh and eighth successive crops upon this land. The two fungous enemies under consideration are the pod-spot (*Colletotrichum legenarium* Pass.) and the bacterial blight (*Bacillus Phaseoli* Sm.), both of which have been present to some extent since the first crop in 1894.

One row each of the six varieties of beans was grown the present season in each belt, in place of the single sort in previous years, the purpose being to make a test of the comparative susceptibility of the various sorts. Beginning at the left-hand (east side) of the plot the order of the varieties was as follows: (1) "Green Flagolet," (2) Currie's "Rust-proof," (3) "Early Mohawk," (4) "Improved Golden Wax," (5) "Extra Early Refugee," and (6) "Saddle-back Wax," as shown in Figure 22, and all were planted upon April 28th. Belt 1 was sprayed with soda-Bordeaux, belt 2 with hydrate, belt 4 with Bordeaux, and belt 5 with potash-Bordeaux, each five times and upon the following dates: May 22d, June 2d, 11th and 23d, and July 8th. The lower end of belt 6 was shaded with lath the same as for the various other crops.

It was noted that the beans under the shade were about two days behind the others in breaking ground. Four weeks after planting it was observed that the shaded plants had larger and darker-green leaves than those in the open, and that the tubercles were less numerous upon the roots in the shade than elsewhere. Early in July, during a dry spell, it was seen that the shaded vines had a fresh appearance, while those in the full sun were yellow and wilted. Almost no blight or anthracnose appeared anywhere.

The crop was harvested upon July 31st, and the accompanying table gives the results by belts in pounds of pods: *

	Belt 1.	2.	3.	4.	5.	Total.	Avge.
Plot I., Series V......	21.25	23.75	27 25	21	19.25	112.50	22.5

* Owing to almost daily rains for two weeks, the harvest was delayed, and the foliage having nearly all fallen, the weights of vines were not taken.

It is seen that the check belt is ahead of all others, but it is to be borne in mind that for this crop there was no appreciable blight, and also it should be stated that upon the young bean plants the various fungicides had a slight burning effect. The following note was made upon June 22d: "The fungicides in the first application 'touched' the foliage, but the plants quickly outgrew the 'bronzing.' These results were similar to those with lima beans, but not so extensive, and soda- and potash-Bordeaux marked the foliage more than the Bordeaux. The hydrate was practically 'harmless.'" The crop results accord with these observations.

The following is the amount for each variety:

(1) Green Flagolet.........	21	pounds.	(4) Golden Wax............	12.5	pounds.
(2) Currie's Rust-proof....	13.75	"	(5) Early Refugee.	14.5	"
(3) Early Mohawk.........	30	"	(6) Saddle-back Wax......	20.75	"

The Early Mohawk proved the most productive variety, and the Golden Wax the least. The latter is the sort that had been grown upon the ground for six successive crops.

The primary object of the shading upon belt 6 was to determine the influence of less than normal sun exposure upon the development of fungi, but this was seriously interfered with by the blights being almost entirely absent from all portions of the plot. It was, however, determined that half-shading prolongs but does not shorten the crop and may prove advantageous. This fact is considered more fully under "Experiments in Shading Plants," elsewhere in this report.

In Plot II., Series III., a duplicate of the above experiment was carried out, it being ground new to beans, while the other, as before stated, was upon old bean land. Both plots were planted the same day (April 28th), and treated alike in every way, except that no shading test was made upon the new land. The plants grew more vigorously in the old land, and an examination of the roots of several plants from each variety in the two plots leads to the fact that when the plants were four weeks old there were no tubercles upon the roots grown in the new soil, while all plants from the old bean soil had an abundance of large tubercles. During June the difference in size, color, etc., between the plants upon the old and the new ground was considerable, and but few tubercles formed upon the roots of the latter. At harvest the differences in the total weights of pods were not great,

as shown by a comparison of the table below with the similar one for the old land:

	Belt 1.	2.	3.	4.	5.	6.	Total.	Avge.
Plot II., Series III.....	12 pounds.	17	21.75	22.25	14.5	20	107.5	17.9

The average upon the old land is 22.5 pounds to 17.9 for the new. The following table shows the amount for each of the six varieties:

(1) Green Flagolet..........	24 pounds.	(4) Golden Wax.............	11.5 pounds.
(2) Currie's Rust-proof......	14.5 "	(5) Early Refugee..	12 "
(3) Early Mohawk..........	27 "	(6) Saddle-back Wax.......	18.5 "

Here, as in the old ground, the "Early Mohawk" has proved the most productive variety and the "Golden Wax" the least. The second and third most productive sorts are also the same in both plots.

Second Crop of Wax Beans.

Two plots previously in beans, above recorded, were planted for the second crop upon July 31st, and with the same varieties and in the same order as for the first crop. The plants appeared above ground upon the seventh day after planting, except those under the shade, which were about two days later. The treatment with fungicides, belt by belt, was the same as for the first crop, and the five sprayings were upon the following dates: August 10th, 24th, September 8th, 21st, and October 5th. Plants receiving the soda-Bordeaux were somewhat smaller than the check. Upon August 30th blooms began to appear upon Early Mohawk and Saddle-back Wax, and the plants upon the old bean land were somewhat ahead of those upon the new ground. Upon September 3d bacterial patches were found upon the leaves of the Green Flagolet. Later in the season this leaf-blight was seen upon the Early Refugee, and to some extent upon Currie's Rust-proof, the remaining three varieties being comparatively healthy.

For the purpose of testing the influence of thinning upon the development of the blights, one-half of the plot had the plants thinned six inches apart and the other half to three inches; in short, one-half was thinned as usual and in the other the plants were left twice as thick.

In weight of vines it was found that the thinned half of the plot is to the unthinned as three to five, that is, a double of the number of the plants adds somewhat more than a half more of weight. The difference in the total weight of sound pods is almost exactly as two to three in favor of the unthinned portion. In other words, where the

plants are double in number the weight of pods is increased one-half more; for example, the thirty plants in any given half row, thinned to six inches, give two-thirds as many pods by weight as the sixty plants three inches apart in the remaining half of the same row.

The diseased pods upon the thinned half of the plot are in weight to those of the unthinned portion as five to six. Therefore there is less difference between the amounts of diseased pods than between the sound pods; or, in other words, the thinning of wax beans from three inches to six inches in the row does not materially affect the amount of disease upon the plants thus treated.

In view of the fact that no difference exists between the thinned and unthinned, so far as diseases are concerned, in the further consideration of the influence of spraying and effect of variety of bean upon these diseases, the weights of the whole belt will be used, regardless of the feature of thinning above mentioned.

The following table records the number of pounds of sound and spotted pods in terms of sprayed belts:

	Belt 1.	2.	3.	4.	5.	Total.	Avge.
Sound	22.25	24.5	26.75	27.5	23.75	124.75	24.95
Spotted	2.75	4	6.75	3.75	2.5	19.75	3.95
	25	28.5	33.50	31 25	26.25	144.50	28.90

In total yield the check is ahead, as was the case in the spring crop, followed by the Bordeauxed belt. It is not unlikely that differences in the soil may account for this uniformity, especially with belt 1, which is the lowest in both crops. In amount of diseased pods, the check leads, while the potash-Bordeaux gives the best results, and the Bordeaux is third best.

The following table shows in pounds the relative susceptibility of different varieties to the fungous diseases of beans:

	Sound.	Spotted.	Rank.
(1) Green Flagolet	13.25	8.75	1
(2) Currie's Rust-proof	16	3.25	2
(3) Early Mohawk	23	2	3
(4) Golden Wax	21.75	1.5	4
(5) Early Refugee	23	1	5
(6) Saddle-back Wax	24	3.25	2

It is seen that the "Green Flagolet" is very much more susceptible than any other variety, while "Currie's Rust-proof" and the "Saddle-

back Wax" are both in the second place. The "Early Refugee" is the least susceptible of the six sorts here tested.

In the new ground the record by belts in pounds is as follows:

	Belt 1.	2.	3.	4.	5.	6.	Total.	Avge.
Sound	21	23	20.75	26	28.25	25	144	24
Spotted.	3.75	4.75	12.75	4.5	2.5	8	36.25	6.04
	24.75	27.75	33.50	30.5	30.75	33	180.25	30.04

In total yield there is no great difference among the belts, and attention is drawn only to the amounts of diseased pods, which are

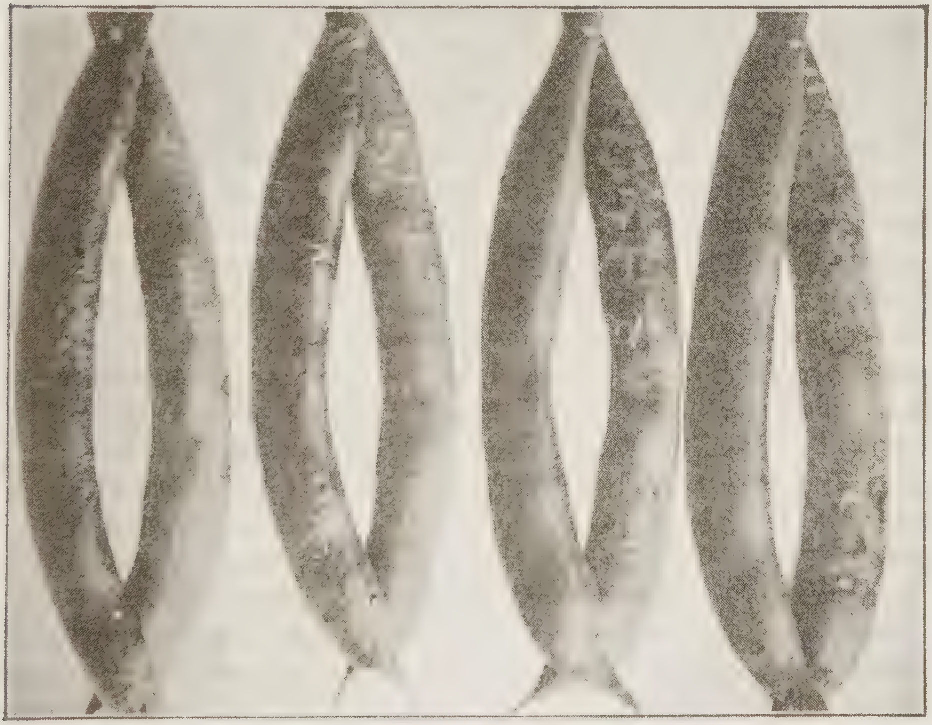

Fig. 23.
Four Pods of Green Flagolet Showing Bacteriosis upon the Side most Exposed to Sun, etc.

seen to be much larger in the check belts (3 and 6) than elsewhere, and there is no great difference in the action of the fungicides, they being effective in the following order, beginning with the best: Potash-Bordeaux, soda-Bordeaux, Bordeaux, and hydrate.

The susceptibility of the different varieties is shown in the following table:

	Sound.	Spotted.	Rank.
(1) Green Flagolet	10	15	1
(2) Currie's Rust-proof	24.75	5.75	3
(3) Early Mohawk	26.25	6.5	2
(4) Golden Wax	27.5	3	4
(5) Early Refugee	29	2	5
(6) Saddle-back Wax	26.5	3	4

This shows that the Green Flagolet is very much more attacked by the blights than any of the other five sorts. The first three in the list are the most susceptible upon both plots. Figure 23 shows four pods of Green Flagolet in which the bacteriosis is confined to one side that was more exposed to sun, etc., than the other.

CRIMSON CLOVER DISEASE.

One of the crimson clover fields at the College Farm was unusually spotted last spring, due to the dying of a large percentage of the plants. In some places, of a square rod or more in extent, all the clover perished before it came into blossom, while elsewhere in the field only here and there a plant failed. These plants did not all die at once, but continued to perish throughout several months, and, for aught that is known, some may have died in the previous autumn. Some plants attained half a full growth and then perished. A view of the field in part is seen in Figure 24. When the field was first examined in April many of the clover plants were already dead, and the brown foliage was prostrate upon the ground; other plants were smaller than usual and the foliage of a sickly, somewhat mottled appearance, the leaf-stalks short and upright, giving such stools a dwarfed and "bunchy" form. Upon warm days, when the healthy plants were growing rapidly, the sickly plants failed to enlarge and wilted.

An examination was made of the diseased plants, and they were uniformly found to be the victims of a fungus that was sending its coarse cobwebby threads all through the leaves, down the petioles and into the roots. The soft tissues of the leaflets were more easily attacked than the denser parts, and when these were upon the ground or near a diseased plant they became more or less mildewed, then wilted and shortly died.

At the crown in the soft central tissue of the stem the fungus *Sclerotinia trifoliorium* Eriks. produce sirregular masses, varying in size from a mustard seed to a pea, at first white and soft, but passing in color through olive to black, when they become dry and hard as

Fig. 24.
A Portion of the Clover Field Injured by the Root Disease.

horn. At the bases of the prostrate branches of the dead plants from one to a dozen or so of these dark bodies could usually be found, sometimes attached to the surface of the branch or imbedded within its tissue or that of the crown or the root below the surface of the soil. Figure 25 gives the roots of three dead clover plants, showing

the clusters as dark masses at the crown. Upon one of the roots two young and whitish sclerotia or fungous masses are to be seen.

This fungous enemy is not a new one, it being recorded upon the clover as a destructive pest for Europe, and more recently it has been complained of by the growers of crimson clover in Delaware and studied by the Botanist of the Experiment Station of that State.

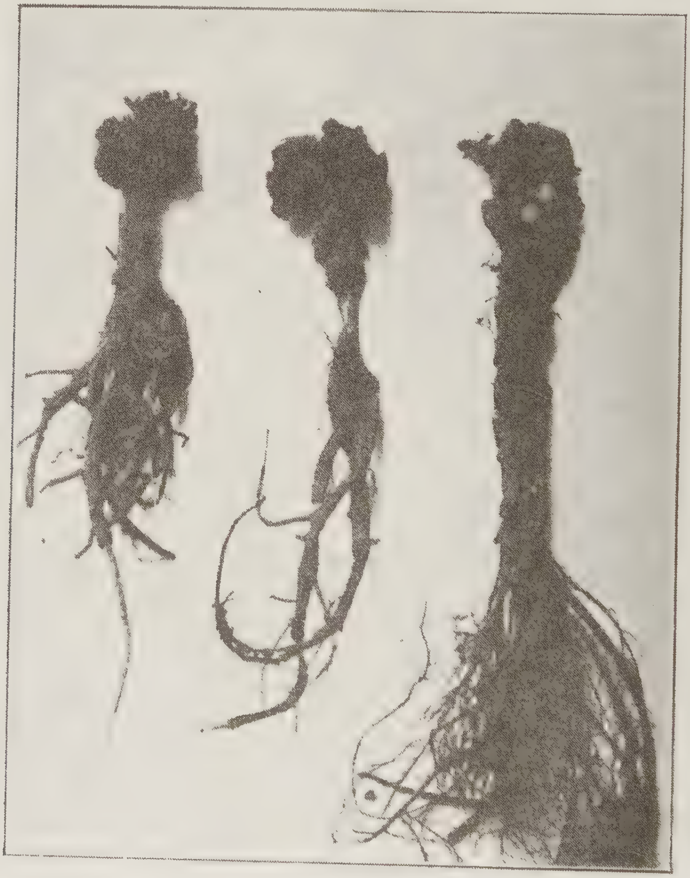

Fig. 26.
Roots of Dead Clover Plants Showing the Sclerotia at the Crown.

Desiring to study further the clover Sclerotium in the field, a piece of land, belts 5 and 6, Plot II., Series VI., in the Experiment Area, was set apart and three bushels of the dead clover plants and adhering soil placed upon the surface after sowings were made May

20th, in drills, of the following species of clover and clover-like plants:

Trifolium arvense L.	*Melilotus officinalis* (L.)
Trifolium pratense L.	*Lespedeza striata* Thum.
Trifolium hybridum L.	*Lespedeza capitata* Michx.
Trifolium repens L.	*Strophostyles helvola* (L.)
Trifolium incarnatum L. (Seed from Henderson.)	*Onobrychis viciæfolia* Scop.
Trifolium incarnatum L (Seed grown on College Farm.)	*Cassia Marylandica* L.
Melilotus alba Desv.	*Medicago sativa* L.
	Medicago lupulina L.
	Crotalaria sagittalis L.

The seeds of a number of the species failed to grow, but the crimson clover in both instances came up well in the land having received the virus as a light mulch, and also in the adjoining check belt, where no diseased plants had been added. Within five weeks signs of disease in the young plants could be unmistakably determined. During this time there was a long dry spell, not conducive to either the growth of the clovers or their enemy. The drought was succeeded by a prolonged wet spell, and it was in the midst of this latter that the clover plants showed the sickness in form identical with that above described for the field plants in the spring. There was the dwarfed condition of the plants, the short, contracted, mottled foliage, followed by the wilting and death. A microscopic examination showed the stout cobwebby filaments, which quickly fastened the leaves together and caused them to rot. A diseased plant placed upon a healthy one in a moist chamber communicated the fungus to the latter to such an extent in twenty-four hours that all leaves in contact with the former were disorganized by the fungus. Figure 26 shows the diseased plant upon the left and this one was placed upon the one shown at the right. The photograph was taken after twelve hours, and at that time the large plant was nearly overrun with the fungous threads developed from the diseased plant.

Some few of the plants in the adjoining check belt of land showed the same sickness as in the area receiving the diseased plants as might be expected in a field trial of this sort.

The experiment, however, shows that the disease may be conveyed from one place to another in the affected plants, and will bring ruin in the short space of two months, necessarily attacking the plants when they are quite small.

Of all the clovers tested the crimson is the most susceptible, and, in fact, was the only one up to July 27th that had suffered from the spread of the virus.

Nothing points to the opinion held by some that the disease is

Fig. 26.
Diseased Plant upon the Left, Freshly Inoculated one at the Right.

transmitted in the seed, and as the resting form of the fungus, the dark, hard bodies, are upon and in the soil, it goes without further writing that a field once badly infested with this disease should be plowed and put into some other crop for a term of years.

Black Mould of Scarlet Clover.

The foliage of the scarlet clover (*Trifolium incarnatum*) during June was badly attacked by the fungus *Polythrincium trifolii* Kunz, the conidial form of *Phyllachora trifolii* Pers. This fungus causes dark, almost black, well-defined, minute, round dots upon the under side of the leaf, with corresponding light-green spots upon the upper side.

Each dark speck is made up of a multitude of dark threads that consist of minute cells placed like beads in a necklace, and bear a two-celled spore at the free end. For America, in "Farlow's Host Index," this fungus is recorded for the common red clover (*Trifolium pratense* L.), the white clover (*Trifolium repens* L.), and Saccardo mentions three other species of clover, besides species in the genera Lepedeza and Pentaphyllum, closely related to clovers, but does not give the present host.

EXPERIMENTS WITH CUCUMBERS.

Plot III. of Series V., upon which cucumbers had been grown in 1895 and 1896, was again devoted to experiments with that crop the present season. Cucumbers are often seriously injured by two fungous enemies, the mildew (*Plasmopara Cubensis* B. & C.) and the anthracnose (*Colletotrichum legenarium* Pass.)

Sprayings were made with the four fungicides generally employed through the Experiment Area, and one row in belt 6 was shaded. Five varieties were planted in each belt, May 15th, as follows: (1) Everbearing, (2) Small Gherkin, (3) Early White Spine, (4) White Pearl and (5) Japanese Climbing (see Figure 27), for the purpose of making a comparative test of their susceptibility to disease. Each variety constituted one row extending lengthwise across the entire plot, the first row on the upper side being the Everbearing and the others following in the order named above. There was no marked difference in the time required by each variety for germination, whether shaded or exposed. As in 1896, the experiment was seriously interfered with by the attacks of the striped cucumber beetle, the row of Gherkins being so nearly destroyed at the outset that it was replanted June 8th.

Eight applications of the four fungicides were made, the first spraying being June 11th, the last September 8th; the intervals between sprayings ranging from nine to sixteen days. The Everbearing and

Japanese Climbing came into blooming June 25th, or nearly one week in advance of the White Spine, and fully two weeks ahead of the White Pearl and Gherkin, due allowance being made for re-planting of the last-named variety. Blossoms appeared upon the shaded vines of the Everbearing sort only one day later than upon the exposed; but with the other four varieties this difference was several days. The blossoms were fewer in the shade than in the open.

By August 21st the shaded vines of the Everbearing, White Pearl and Japanese Climbing varieties were destroyed by beetles, and nearly all those of the White Pearl failed to develop fruits of any size on

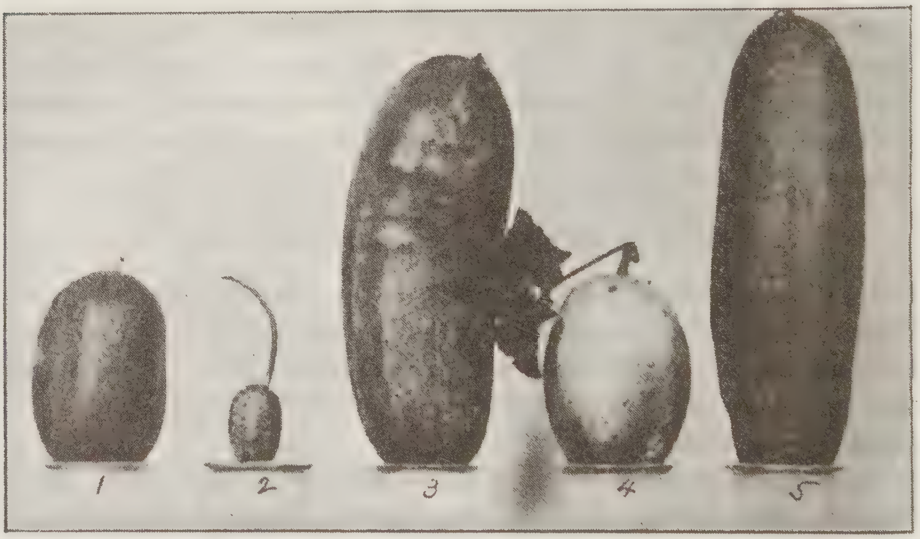

Fig. 27.
Samples of the Five Varieties of Cucumbers.

this account. No blight was noticed until early in September, when the cucumber mildew made its appearance, and soon became much more abundant than it had been upon either of the two preceding crops.

The vines in belts 4 and 5, sprayed with Bordeaux and potash-Bordeaux respectively, were much less infested than those of the check belt—hardly enough, it would seem, to materially affect the yield of fruits. The soda-Bordeauxed vines were considerably more infested than those of the two belts just considered, but suffered much less than did the unsprayed plants. Where hydrate was used the mildew was somewhat reduced.

The cucumber anthracnose, although more abundant in 1896 than the mildew, was not observed the present season. While there has been considerable fruit rot in previous crops, the percentage of loss from this source in 1897 was very small. The fruits were not removed from the ground, and those in the two unsprayed belts became noticeably blackened and decayed, while all others were nearly free from spotting.

In the following table are recorded the weights of the fruits produced upon each belt by each of the five varieties:

	Soda.		Hydrate.		Check.		Bordeaux.		Potash.	
	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.
Everbearing	3	6	5	6	...	...	6	...	10	...
Gherkin	12	6	5	8	2	...	9	6	7	10
White Spine	20	...	16	2	17	6	38	14	30	8
White Pearl	...	10	...	...	...	...	1	8	1	8
Japanese Climbing	4	3	7	9	4	...	6	10	11	...
Total	40	9	34	9	23	6	62	6	60	10

In those belts where no fruits are recorded for certain sorts it may be understood that the vines of that variety were destroyed while the fruits were yet undeveloped. In making a comparative study of the product of the several belts, whether each variety be considered by itself or the five sorts in each belt as a whole, there is in either case a decided difference in favor of the vines in the Bordeaux and potash-Bordeaux belts. Taken as a whole, there is a slight difference in favor of Bordeaux, but the reverse is true in case of certain varieties. Soda-Bordeaux for some varieties gave better returns than where nothing was applied, which is also true of the belt as a whole. In only one instance, that of the Gherkin, is there a larger yield in the soda-Bordeauxed belt than in the Bordeauxed and potash-Bordeauxed belts. For the remaining four varieties the yield is considerably lower than where the last two mentioned fungicides were applied. The results in the hydrate belt, so far as indicated by the weight of fruits produced, are nearly the same as those obtained in the soda-Bordeauxed belt.

For only two varieties is it possible to make a comparison of the yields of the shaded and exposed hills, on account of the shaded vines having been destroyed by beetles. No fruits were set upon the shaded Gherkin, while the exposed vine beside it produced a trifle over 7 pounds.

Upon the shaded vines of the White Spine there were 4 pounds of fruit, and upon the exposed, 8½ pounds. Judging from the difference in the number of blossoms observed earlier in the season, it is believed that the above difference in the weight of fruit, of something over 100 per cent. in favor of no shade, may be taken as a liberal estimate of the relative productiveness of shaded cucumber vines and those that are exposed.

The presence near the Experiment Area of a hop vine badly infested with an anthracnose (*Colletotrichum Sp.*), suggested the idea of an attempt to determine if the foliage of the cucumber might not be inoculated with the above disease. A considerable number of the hop leaves were therefore collected and placed between strips of netting and suspended a few inches above one of the cucumber vines. The attempted inoculation was made June 10th, and although the diseased hop leaves remained in position for the rest of the summer, no disease, other than the mildew, appeared upon the cucumber foliage in question.

EXPERIMENTS WITH PEAS.

Plot IV. of Series V. was devoted to peas for the first time in 1896.* Three crops were grown, and the last two were quite seriously attacked by three forms of disease, all of which prey upon both the stem and leaf of the pea, and one extends its attack to the underground portion of the stem, and is on this account more destructive than either of the other two. It was for the purpose of controlling this last-mentioned disease that soil applications of sulphur, corrosive sublimate, carbonate of lime and copper sulphate were made in June, 1896, to the soil of the first four half belts. The effect of these soil fungicides upon the stem disease of the pea was again tested the present season.

Peas of the "American Wonder" variety were sown April 7th. In addition to the experiments with the four soil fungicides the lower third of belt 6 was shaded. Belts 3, 4 and 5 were untreated.

The rate of germination was quite uniform throughout the first five belts; but in the shaded portion of belt 6 the young plants did not make their appearance as early as those in the exposed portion of the same belt. For example, upon April 22d there were 33 plants breaking ground under the shade, and 212 in the corresponding area

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*For an account of the experiments with peas in 1896, the reader is referred to the Annual Report of this Station for 1896, pages 345, 346.

in the open. After the first ten days the slow development of the shaded plants was still more noticeable and the contrast became greater as the season advanced. The shaded vines were smaller, did not come into bloom until about ten days later than the exposed, and pods of a marketable size were not developed beneath the shade until fully two weeks after they were ready elsewhere.

After the first month the vines in the sulphured soil were somewhat smaller than those in adjoining soil-treated areas or the checks; they, however, blossomed and matured their fruits fully as early as any other unshaded vines.

Two fungous diseases began to develop somewhat upon the first crop in 1897, namely, the Blight *Ascochyta Pisi* Lib. and the Mildew *Erysiphæ Martii* Lev. A third disease, partially underground, seemed to be of bacterial origin. None of the three diseases developed sufficiently to appreciably harm the first crop. The vines stood until the pods were ripe, when the crop was harvested. The results of the harvest in terms of pounds, for the first four half belts, and for the first three rows in belt 3, untreated, are given in the following table, together with the product of the shaded and exposed areas in belt 6. The yield in every instance is expressed in terms of entire belts:

	Sulphur.	Corrosive sublimate.	Carb. lime.	Copper sulphate.	Check.	Exposed.	Shaded.
Vines and pods....	9.5 lbs.	14	13	13	11	9	6
Peas	12.5 lbs.	16.5	16	14	12.5	10.5	5.25

The largest yield was obtained from the two half belts treated with corrosive sublimate and carbonate of lime respectively; that of each being about 25 per cent. higher than the product of the check, with a difference in the weight of vines and pods in favor of the fungicides of 21.5 per cent. in case of corrosive sublimate, and almost 15 per cent. in case of carbonate of lime. The yield of vines from the carbonate of lime and the copper sulphate areas was the same, but somewhat less seed was produced upon the latter, although it exceeded the yield of the check by about 11 per cent. In the sulphured half belt the yield of seed equaled the check, but its vines weighed less by about 14 per cent.

A striking result was obtained in the shaded portion of belt 6, where it was shown that the exposed produced just twice as much seed as the shaded ground, but the weight of vines was much less than double.

The Second Pea Crop of 1897.

Upon July 17th, the plot was again sown to "American Wonder" peas. Experiments with soil fungicides and shading were continued, in addition to which the second crop was sprayed. The plot was divided lengthwise into five equal belts, four of which were sprayed with soda-Bordeaux, hydrate, Bordeaux and potash-Bordeaux respectively, while the middle belt served as a check. Five applications were made upon the following dates: July 23d, August 2d, 11th, 24th, and September 8th. All fungicides failed to adhere sufficiently to make them of any practical value. The peas were considerably blighted and the sprayed were seemingly as much infested by Ascochyta and the bacterial disease as the unsprayed. The mildew (Erysiphe), however, was somewhat more abundant upon the unsprayed vines. The results from spraying the second crop of peas are shown in the accompanying table.

	Vines.	Pods.
Soda	26.25 lbs.	12.5 lbs.
Hydrate	26.5 "	12 "
Check	20.25 "	20 "
Bordeaux	21.25 "	12 "
Potash	16 "	8 "

From the above table it may be seen that the weights of vines produced upon the sprayed belts were slightly higher than those from the unsprayed. The potash-Bordeauxed vines were uninjured by the fungicide, but the stand was poor in that belt.

With the exception of the sulphured half belt, the product of the soil-treated area was somewhat higher than that of the check belts. Where carbonate of lime was used, 43 per cent. more vines were produced than the average of the check and 29 per cent. more pods. The yield of the corrosive sublimate half belt was somewhat lower than that of the one treated with carbonate of lime, but considerably higher than the average of the checks. The yield of vines from the sulphured soil was about 9 per cent. and of the pods 16 per cent. lower than that of the checks.

Comparing the product of the shaded with that of an equal exposed area in the same belt, there was a difference in weight in favor of the unshaded vines of almost 100 per cent., and of pods of a little more than 200 per cent. Mildew was somewhat more abundant under the shade, but the Ascochyta and the bacterial disease thrived best in the open.

Experiments with Carrots.

Plot IV., Series VI., was sown to carrots for the first crop and followed by celery, the leading thought in this being to occupy the ground with a crop allied to the celery and thereby, possibly, to increase the amount of fungous enemies upon the celery. Previously in the experiments with celery upon the Experiment Area there has been a lack of blights, thus rendering the tests of the various fungicides upon this crop of but little value.

Fig. 28.

Sample of each of the Six Varieties of Carrots, the Lower Row being from the Shaded Ground.

Six varieties of carrots were grown, a row of each in each of the six belts, as follows, beginning at the left side of the plot: Early Scarlet, Guerande, Early Half-long Carentan, Long Orange, Large White Belgian and Danvers Half-long. Figure 28 shows an average specimen of each variety, much reduced, and in the lower line a corresponding set from the shade.

No spraying was given to the plot and all belts were alike in all possible respects except No. 6, one-third of which was covered with the lath half-shade.

In degree of blighting there was some difference among the varieties, the worst being the Long White Belgian, the next the Early Half-long Carentan, and the third the Long Orange, while the last was the Danvers Half-long; the next the Early Scarlet Horn and the Guerande.

After seventeen weeks' growth, from April 8th to August 6th, the plants were harvested row by row, and the tops and roots weighed with the following results:

		Tops.	Roots.	Rank.
No. 1.	Early Scarlet Horn	41 lbs.	81.75 lbs.	4
No. 2.	Guerande or Oxheart	53.50 "	106 "	2
No. 3.	Early Half-long Carentan	14.75 "	49.75 "	6
No. 4.	Long Orange	85.75 "	93.50 "	3
No. 5.	Large White Belgian	59.75 "	65 "	5
No. 6.	Danvers Half-long	78 "	111 "	1
	Total	332.75 "	507.00 "	

No attempt was made to determine the relative market value of the different sorts.

In belt 6 a shading experiment was carried out as mentioned for other crops. The results are entirely against the use of shade for carrots. The following table gives the weight of the tops and roots in the shaded area as reduced to terms of a belt:

	Tops.		Roots.	
	Shade.	Sun.	Shade.	Sun.
No. 1	6	10.87	9.75	24
No. 2	6.75	10.50	11.25	25.50
No. 3	2.25	3	6.75	15.75
No. 4	12	15.75	8.25	20.62
No. 5	11.25	15	7.50	17
No. 6	12	29.62	12	20.25
	50 25	84.74	55.50	123.12

It will be seen that there was much less difference between the tops of the shaded and fully exposed areas than the roots.

EXPERIMENTS WITH CELERY.

Plot IV., Series VI., was set to celery upon August 10th, it following the early crops of carrots previously mentioned. Six varieties were used, as follows: "Perfection," "Giant Pascal," "Pink Plume," "Golden Dwarf," "White Plume," and "Golden Self-blanching," and, so far as possible, each belt was a duplicate of all the others. One-third of belt 6 was given to an experiment in shading. For purposes of spraying the plot was divided lengthwise into five equal strips, the middle one being reserved as a check, while the other four were sprayed seven times with soda-Bordeaux, hydrate, Bordeaux and potash-Bordeaux respectively upon the following dates: August 12th, 24th, September 8th, 21st, October 4th, 14th and 28th.

The unusual freedom of all plants from the celery blights was remarkable and prevented any record being made as to the value, absolute or relative, of the four fungicides used.

The shading, upon the other hand, gave a striking difference, the plants under the laths beginning to gain upon the others from the day they were set out, and after one month they were fully twice as large as those not so protected from the sun.

At the time of harvest the weights of the clean celery from the shaded ground was 150 pounds, while a corresponding area in the open produced 171 pounds. Something further is written of this result under the head of "Experiments with Shading."

EXPERIMENTS WITH BEETS.

Series O of the Experiment Area has been devoted to beet experiments for the past four seasons, the chief purpose of the work being to control, by the use of fungicides, the beef Leaf Spot (*Cercospora beticola* Sacc.)*

Previous to 1897 but one variety of beets, the Colossal Long Red Mangel-wurzel, had been grown. The application of fungicides to the

* Bulletin 107, "Some Fungous Diseases of Beets," contains a description of the Cercospora and other fungous enemies peculiar to beets in this country, together with an account of the beet experiments conducted upon the experiment area for the year 1894. For a full account of this department's work with beets during the next two years the reader is referred to the Annual Report for 1895, pages 328, 329 and 333, and that for 1896, pages 346 to 350.

foliage of this beet has been attended with decidedly favorable results, as shown in records cited below.

During the present season one portion of the beet experiments consisted in a study of the comparative susceptibility of different varieties to disease, and five different commercial sorts were grown as follows: Long Smooth Blood-red, Swiss Chard, Colossal Long Red Mangel-wurzel, White Sugar and Early Yellow Turnip.

Beet scab, noted but occasionally upon the roots of the first crop of mangels, has become much more prevalent upon the two succeeding crops, and the present season the condition of the roots of different varieties of beets with regard to their relative scabbiness has been made a subject of observation as well as the comparative spotting of the foliage.

Since the beet is so generally infested by leaf fungi, it has been a favorite subject during the past four years upon which to make comparative tests of different fungicides. More of this kind of work was introduced in connection with the crop of 1897 than with any preceding it, eleven compounds being sprayed upon the foliage of the different belts. The three soda-Bordeauxs were formed by adding to solutions of copper sulphate three different commercial brands of soda. Cupric hydrate was prepared by taking the dried (or, if not dried, thoroughly washed) precipitate of soda-Bordeaux and stirring it up again with the requirad quantity of water. The two Bordeauxs used differed only in the percentage of lime which they contained. The sulphates of soda, lime and potash are presumed to be practically the same; but this test was made to ascertain if any or all were of value as fungicides or the reverse. Water was sprayed upon the beets so treated at the same time that Bordeaux and sulphates were applied elsewhere; the purpose in this instance being not to prevent blight, but to determine whether or not this additional moisture upon the foliage would materially increase the percentage of disease. It will be noted that two belts were sprayed with each of the Bordeauxs and with cupric hydrate. Water and the sulphates were each applied to but a single belt.

The seed was sown April 19th, and with the exception of three or four belts a fairly uniform stand of plants was obtained throughout the series. Spraying began May 22d, when but little more than the first leaves had developed, and was repeated upon the following dates:

June 2d, 11th and 23d, July 7th and 23d, August 2d, 11th and 24th, and September 8th; in all, ten applications.

Leaf-spotting was first noted the last week in June. In the check belts it increased rapidly, and at the end of one month there was a decided contrast between the unsprayed belts and those treated with fungicides. All three of the sulphates proved alike ineffective, and the beets to which they were applied seemed as badly spotted as those unsprayed. Disease was thought to spread somewhat more rapidly in the belt sprayed with water than in the check beside it. In the hydrate belts, while the Cercospora developed somewhat more slowly than in the checks, the plants so treated suffered more severely than those sprayed with the Bordeauxs.

In the belts sprayed with the six forms of Bordeaux disease developed but slowly, and there was no marked contrast in favor of any one of the mixtures. September 24th, a few days previous to harvesting the crop, an estimate was made of the relative amount of leaf-spotting upon differently treated belts. As might be expected, the contrast between certain belts was much less pronounced so near the close of the season than was the case a month or six weeks earlier. There still remained, however, a very noticeable difference in favor of the Bordeauxed belts, the percentage of blight in all of which was estimated to be about one-half that in the check belts. The belt sprayed with water and those sprayed with the sulphates seemed to be fully as much infested by disease as the checks. In the hydrate belts, while the degree of spotting was somewhat less than in the checks earlier in the season, no essential difference could be detected between them and the unsprayed at time of harvesting.

The shaded beets throughout the summer were noticeably freer from disease than the exposed plants in the same belt, and at time of harvesting the amount of leaf spot upon them was estimated to be only about one-half as much as upon the exposed plants.

In connection with this experiment, it should be stated that the land occupied by the beet series was somewhat uneven, and, in order to get a uniform surface, grading to some extent was done in the spring of the present season. This was after the manure had been added and the ground plowed, and as a result the best soil in some parts was scraped into the lower places at the expense of the fertility of the spots that were lowered to the common grade. On account of

the unevenness of the land, the weights of the roots, as recorded for the belts, do not give the full meaning of the treatment with fungicides that they have received. In a general way, the grading was from Plot I. down to Plot IV., the land being an incline, and the weights showed that the lower belts profited by the operation, while those in the upper plot suffered considerably.

Even with this disturbing element in the grading of the series, the yield of the check belt was the lowest in each of the plots, and Bordeaux the highest in Plots I. and III., while "Babbitt's lye" led all others in Plot IV. In Plot II. the Bordeaux was exceeded slightly by the sulphate of soda, a fact that is explained by the much smaller number of plants in the Bordeaux belt, namely, 198 to 262 in the sulphate belt, so that the average weight of the roots is much better where the Bordeaux was used.

Potash-Bordeaux was next to Bordeaux in Plot I., but only a little better than the check in the other plot where it was used. In a similar manner, soda-Bordeaux was next to the check in Plot I., and second only to Bordeaux in Plot III.; all of which confirms the opinion that the soil was not sufficiently uniform for satisfactory results, and suggests the advantage of using long strips of land instead of rectangles for an experiment of this kind, where the soil is "spotted."

From the record of percentages of leaf blight, it is gathered that the most susceptible variety of beet is the Mangel-wurzel, second the Swiss Chard, medium the White Sugar, while Early Yellow Turnip follows next, and the Long Smooth Blood-red is least affected of all.

Late Crop of Beets.

As a second crop after Early Rose potatoes, three varieties of beets, namely, the "Long Dark Blood-red," "Swiss Chard" and "Mangel-wurzel" were sown August 9th in Plots I. and II. of Series VI. Here the soil of certain belts had received different amounts of corrosive sublimate in Plot I. and sulphur in Plot II. Each plot was divided lengthwise into three strips, making six in all, the first, third, fourth and sixth being sprayed six times with soda-Bordeaux, hydrate, Bordeaux and potash-Bordeaux respectively.

The beets grew well during the autumn months, and made a profitable crop. All of the fungicides except Bordeaux burned the

foliage of the young plants to some extent, and the spots thus produced were the only ones upon the leaves, as no blights appeared. This is the second test that has been made with a late crop of beets without the Cercospora appearing. It has been noted elsewhere that the foliage of early-sown beets improves greatly after the middle of September, in that the new foliage formed after that date is not damaged by the Cercospora.

Upon November 18th the crop was harvested and the roots examined for the scab, that it was expected they would contract from a soil where the Oospora had attacked the potatoes in the previous crop.

If the amount of scab is placed as one for the sulphured soil that for the belts where corrosive sublimate was used would be four and five for the checks. In short, there was a very marked reduction of the trouble in the soil where sulphur had been added the summer previous.

Supplemental Beet-Weed Series.

As a test of the influence of weeds upon the soil and crop, a strip of land 138 feet long and 11 feet wide was sown April 19th to the same kinds of beets as were used in the adjoining beet series, one row of each kind running lengthwise of the strip.

The following was the schedule for cultural attention to be given to the experiment:

Sow beets as in Series O, and broadcast weed seeds upon the ground.

In the belt adjoining Plot I. of Series O, the care was the same as for the beets in Series O, namely, three hoeings, as follows: Upon May 10th, 18th, and July 26th.

In the belt adjoining Plot II. there was no care given excepting the thinning of the beet seedlings to proper distance.

In the belt adjoining Plot III. the care was five hoeings, namely, upon May 10th, 18th, June 12th, 19th, and July 26th.

In the belt adjoining Plot IV., the care was seven hoeings, as follows: May 10th, 18th, June 12th, 19th, 28th, July 6th and 26th.

The whole area was sown with weed seeds, eight ounces being used and made up of thirty kinds of weed seeds, as given in the list below:

1. *Ranunculus bulbosus* L.
2. *Brassica campestris* L.
3. *Allaria Allaria* (L.)
4. *Lepidium campestre* L.
5. *Camelina sativa* L.
6. *Abutilon Abutilon* (L.)
7. *Agrostemma Githago* L.
8. *Silene noctiflora* L.
9. *Cassia Marylandica* L.
10. *Medicago lupulina* L.
11. *Melitotus alba* Desv.
12. *Onagra biennis* (L.)
13. *Mollugo verticillata* L.
14. *Daucus Carota* L.
15. *Ambrosia trifida* L.
16. *Arctium Lappa* L.
17. *Chrysanthemum Leucathemum* L.
18. *Hieracium aurantiacum* L.
19. *Rudbeckia hirta* L.
20. *Lobelia inflata* L.
21. *Lappula Lappula* (L.)
22. *Datura Tatula* L.
23. *Linaria Linaria* (L)
24. *Plantago lanceolata* L.
25. *Plantago major* L.
26. *Amarantus albus* L.
27. *Amarantus retroflexus* L.
28. *Chenopodium ambrosoides* L.
29. *Polygonium Convolvulus* L.
30. *Ixophorus glaucus* (L).

All the four belts were sprayed alike with Bordeaux seven times. The amount of time required for hoeing and weeding varied somewhat, but averaged fifteen minutes for each belt, each time, and therefore the labor for each belt and cost of same, at the rate of $1.30 per day, was as follows:

Belt I.	45 minutes,	10 cents.
Belt II.	0 "	0 "
Belt III.	75 "	16 "
Belt IV.	105 "	23 "

The crop was harvested upon September 16th, and the weight of roots for each variety for each belt is as follows:

	Blood Red.	Chard.	Mangel.	Sugar.	Yellow Turnip.	Total.
Belt I.	46.5	11	71	42	23.5	194
Belt II.	24.5	3	6	7.5	2	43
Belt III.	83	15	111.5	87.5	62	359
Belt IV.	70	13	104	86.5	64.5	338

By comparing these totals with those of the adjoining belts in the regular beet series the following showing is obtained:

	Belt 1.	Belt 2.	Belt 3.	Belt 4.
Weed strip	194 lbs.	43 lbs.	359 lbs.	338 lbs.
Adjoining beet strip	137 5 "	119.5 "	214 "	188.5 "

The average of the four belts in the adjoining series is 165 pounds, or somewhat less than belt 1 in the beet-weed series, receiving the same treatment. This is mentioned as the beet-weed belts are on ground new to beets, while the adjoining series has been in that crop

Fig. 29.
A View of Adjoining Portions of a Hoed and an Unhoed Belt of Beets.

for the past three years, which may have something to do with the lower yield. It is also seen that belt 3, in both groups, is the best, and if we take those two we get a fair basis for estimating the value of the additional cultivation were it not for the spraying treatment being different. If we select, therefore, the Bordeaux-treated belt in this plot for comparison, the results are found to be for three hoeings 224 pounds, and for seven hoeings 359, or a difference of 135 pounds per belt due to two hoeings costing 6½ cents, or at the rate of $10 per ton. Under the circumstances it did not pay to hoe beets more than three times, at the cost in the experiment, which was hand labor with a wheel cultivator.

Upon June 28th, after a week without rain, an inspection showed that the beets among the weeds, while much smaller than elsewhere (about half the size), were wilted considerably. The "Swiss Chard," in particular, was so much in need of water that the leaves were lopping and lying upon the foliage and stems of the surrounding weeds. As the beet rows of the weed patch extended out into the portions that were well tended, the illustration of the effect of weeds upon the size and wilting of the crop plants was very striking, and an attempt is made to show this in Figure 29, from a photograph of the belts.

It was noted above that the "Swiss Chard" was the most susceptible to the sapping influence of the weeds. The reason for this is found in the larger percentage of foliage of these plants than the ordinary beets and the structure and position of the petioles. The "Chard" is grown for its leaf stalks, and not the roots, as with ordinary beets. These ribbon-like petioles are broad, fully twice the breadth of ordinary beet petioles, and, more than that, the leaf in the "Chard" stands at an angle midway between that of the vertical and horizontal. The large "Red Mangel," for example, growing in the adjoining row to the "Chard," was suffering but little from wilting, but its leaves naturally stand nearly upright, and a transection of the petiole shows the bundles of fibers disposed in a somewhat D-shaped form, while in the "Chard" they are nearly in a right line and represented by the letter "I" instead of "D." It was suggested that the root system of the "Chard" might be smaller than in other sorts, but an examination of carefully-lifted root systems showed that the ratio between leaf and root area was fully maintained. Microscopic measurements of the thickness of the leaf-blades showed also

that there was no difference here that would help to account for the remarkable susceptibility of the "Chard" to drought, and, while it is not demonstrated that minute structural differences may not have something to do with the behavior of the beets, it seems evident that the disposition of the vascular bundles, the shape of the petioles and the angle which they take upon the plant are among the foremost factors that determine the early wilting of the "Swiss Chard."

Returning now to the weed side of the observations, it need scarcely be said that the ground was thoroughly covered with a long list of these plant-pests. So abundant and rank were they that many of the weeds were also wilting, and it is interesting to note that it was somewhat in the following order:

Alsine media L. (Chickweed).
Silene noctiflora L. (Catchfly).
Helianthus annuus L. (Sunflower).
Malva rotundifolia L. (Mallow).
Portulaca oleracea L. (Purslane).
Daucus Carota L. (Carrot).
Chenopodium ambrosoides L. (Mexican Tea).
Bursa Bursa-pastoris L. (Shepherd's Purse).
Rumex Acetosella L. (Sorrel).
Datura Tatula L. (Thorn-apple).
Ambrosia artimesiæfolia L. (Ragweed).
Hibiscus Trionum L. (Ketmia).
Amarantus retreflexus L. (Pigweed).
Polygonum Persicaria L. (Lady's Thumb).
Abutilon Abutilon L. (Velvet-leaf).

In this sharp struggle many of the smaller or less fortunate weeds had doubtless gone to the wall. Of those remaining, the last six, with the addition of *Helianthus annuus*, seem most likely to triumph.

At the time the patch was examined, when no weeding had been done, the soil was found hard indeed, and the beets that were dug for root-inspection required both much patience and muscular effort, and in this respect differed from the comparatively mellow soil in the adjoining belts.

EXPERIMENTS WITH ORNAMENTAL PLANTS.

About a tenth of an acre, lying between Series VI. and the grass plots, making the border upon the west side of the Experiment Area, is assigned to field tests of fungicides upon the following ornamental plants: Violets, China asters, pinks, nasturtiums, mignonette, phlox, sweet peas, gladiolus, cannas, dahlias, ampelopsis, hibiscus, hollyhocks, redbud and pæonia.

Violets.—The treatment of the violet plants, and the results for the same, are given elsewhere under "Experiments with Violets."

China Asters.—The row of asters, mixed varieties, set May 12th, was divided into six equal sections, the second and fifth, counting from the south end, being checks, and the first, third, fourth and sixth were sprayed ten times with soda-Bordeaux, hydrate, Bordeaux and potash-Bordeaux, respectively, upon the following dates: May 29th, June 12th, 23d, July 7th, 23d, August 2d, 11th, 24th, September 8th and 22d. The leading fungous trouble under investigation was the rust (*Coleosporium*), but it did not appear to any great extent, and the plants were much disturbed by insects, particularly a borer in the stem, to which a general lack of vigor was due in some degree, at least, and so interfered with the growth of the plants as to make any report upon the sprayings of but little value.

Pinks.—The row sown to a mixed variety of pinks was divided into sections and sprayed in the same manner as for asters given above. There was no blight of any sort upon the pinks.

Nasturtium.—The row was sown with a mixed variety of seed and divided and sprayed as for the two previous rows. The bacteria blight appeared in considerable abundance upon the foliage by the middle of June. Long-continuous rains in July started the plants into renewed growth, the blight disappeared and the bloom was profuse. The fungicides seemed to have no effect upon the blight and, in fact, scarcely adhered at all to the peculiar waxy surface of the nasturtium leaves.

Mignonette.—The row sown to a mixed variety of mignonette was sectioned and sprayed seven times as for the last three rows. None of the blight (*Cercospora*) so common to this crop appeared during the season, and the plants did well until overshadowed by the rank-growing nasturtiums alongside.

Phlox.—The row sown to a mixed variety of phlox was sectioned and sprayed nine times. Specimens of leaf blight were found only upon the check plants.

Sweet Peas.—The experiment of last season was repeated as follows:

Section	1.	Seed placed upon surface,	hilled up 5 inches.	
"	2.	" " " "	" " 3 "	
"	3.	" " 2 inches deep,	" " 2 "	
"	4.	" " 5 " "	" " 4 "	
"	5.	" " 3 " "	" " 2 "	
"	6.	" " 1 inch "	" " 1 "	
"	7.	" " 3 inches "	" " 3 "	
"	8.	" " 5 " "	" " 5 "	
"	9.	" soaked in Bordeaux		1 hour, 2 inches deep.
"	10.	" rolled in sulphur		1 " 2 " "
"	11.	" soaked in corrosive sublimate		1 " 2 " "

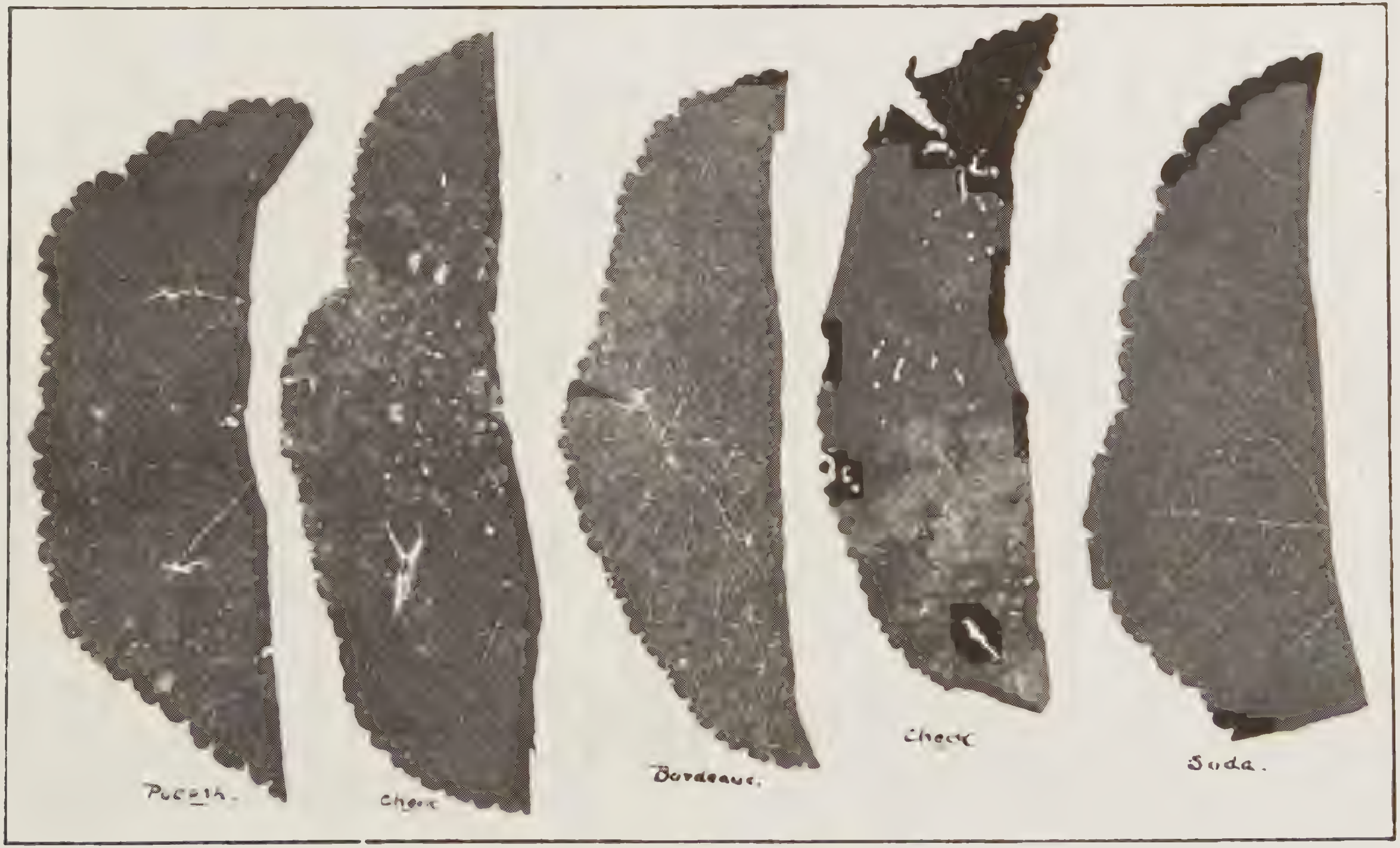
The sowing was upon May 1st, and blooms began to appear upon July 5th. The following is the record of flowers gathered at ten different times during the growing season from July 10th to October 12th:

Sec.	July 10.	17.	24.	Aug. 18.	21.	28.	Sept. 10.	24.	29.	Oct. 12.	Total.
1.	10	75	...	10	3	4	60	...	...	...	162
2.	55	103	12	36	8	16	66	...	...	2	298
3.	60	78	4	46	20	40	30	12	3	22	315
4.	20	88	5	30	8	10	30	11	9	18	246
5.	54	155	52	46	12	20	31	2	6	17	395
6.	5	18	3	10	6	6	28	3	4	15	98
7.	22	122	6	21	7	9	33	5	1	31	257
8.	50	60	20	53	10	22	28	2	1	1	247
9.	50	81	25	28	14	30	65	13	3	2	311
10.	50	107	15	28	16	32	25	26	15	17	331
11.	62	60	10	52	20	40	6	23	20	33	326

From the record it is seen that the largest number of flowers was gathered from section 5, where the seeds were planted three inches deep and hilled up two inches, and the smallest where the seeds were planted one inch deep and hilled up one inch. Outside of the last three sections, where the seed was treated, the second best was section 3, where the seeds were planted two inches deep and hilled up two inches, and the second poorest where planted upon the surface and hilled up five inches. The last three sections all gave good returns in blooms, the rolled in sulphur slightly in excess of the other seed treatments.

Gladiolus.—The row set to gladiolus plants was divided into halves, and the southern half again divided into five equal parts, where variously-treated corms* were set. In the five sections of the northern

*The previous treatment is recorded in the report of this department for 1896, pages 398, 399.


Check
Bordeaux.
Check
Soda.

half of the row the treated corms were set and sprayed nine times, except the check, with the four fungicides in use. No fungous diseases appeared and no differences among the ten sections were observed.

Cannas.—The row set to a mixed variety of cannas was sectioned and sprayed eleven times as for the pinks, mignonette, etc. The plants in all the sections grew well, bloomed profusely and were free from any fungous disease. Some of the foliage in the sprayed sections was burned with the fungicides, the soda-Bordeaux and hydrate causing more than the Bordeaux and potash-Bordeaux.

Dahlias.—The row set to a mixed variety of dahlias was sectioned and sprayed eleven times as for cannas. Many of the plants grew slowly and remained small throughout the season. During July and August the blooms blasted quite generally, and later in the season the flower stalks also blighted considerably alike upon the sprayed and unsprayed plants. A mildew (Erysiphæ) in autumn came extensively upon the unsprayed sections, but was materially checked by the fungicides.

Ampelopsis.—The row set to Boston ivy was sectioned, and sprayed eleven times. All through the season there was a noticeable increase of the leaf blight (*Phyllosticta*) upon the check plants, and some of the unsprayed plants lost nearly all their foliage, while the treated ones were comparatively free from the disease.

Hibiscus.—The row set to hibiscus was sectioned, and sprayed eleven times, as for ampelopsis. The blight so common upon this species in the nursery from which the plants were purchased did not appear upon a single leaf in the whole row, and the only thing to the record for the fungicides is the fact that the first spring foliage was somewhat burned by soda and potash-Bordeaux. Later in the season there was a deeper green observed in the sprayed than in the untreated foliage.

Hollyhocks.—The row set to hollyhocks in 1896 was divided last year into six sections, alternate ones being sprayed with potash-Bordeaux, Bordeaux and soda-Bordeaux, respectively, and the other three remained as checks. The same treatments have been continued the present season.

The thirteen sprayings were upon the following dates: May 22d, 29th, June 11th, 23d, July 7th, 23d, August 2d, 11th, 24th, September 8th, 21st, October 4th and 14th. The plants bloomed freely,

suffered considerably from the June drought and somewhat from lice. The leaf spot (*Cercospora Althæina* Sacc.) appeared upon the check plants early in the season, and increased until its close, but was al-

Fig. 31.
Portions of Most Rusted Leaf of Sprayed and of Unsprayed Hollyhock Leaves.

most entirely absent from the sprayed sections. The engraving, Figure 30, shows portions of sample leaves from the three sprayed and the two check sections.

Upon November 11th the rust (*Puccinia malvacearum* Mont.) was observed for the first time upon the experimental hollyhocks, and a searching examination of all the plants revealed the fact that it was upon all the check plants, with one exception, while only one sprayed section showed any of the disease, namely, the one receiving the potash-Bordeaux, where a few leaves were considerably affected. In Figure 31, the worst portion of the worst leaf from the sprayed plants is shown in contrast with a similar selection from the unsprayed sections placed below it.

Redbud.—The row of *Cercis Japonica*, containing twenty-four plants, set in 1896, was divided last year into halves, each again divided into five sections and sprayed eleven times with potash-Bordeaux, Bordeaux and soda-Bordeaux with alternate sections as checks. When the plants came into bloom in April it was observed that there were more flowers upon the check than the sprayed plants. There has been but very little blight upon the foliage during the whole season, and no marked effect can be recorded for the fungicides.

Pæonias.—The row of peonias, containing twelve plants, set in 1896, was divided into six sections of two plants each, the alternate pairs being sprayed with potash-Bordeaux, Bordeaux and soda-Bordeaux, respectively. The same treatments have been continued the present season. No blight appeared, and this spring the sprayed plants were uniformly smaller than the treated ones. The total blooms upon the plants is as follows: Six unsprayed plants, 58; six with potash-Bordeaux, 15; Bordeaux, 3, and soda-Bordeaux, 12. There were nearly twice as many blooms upon the six unsprayed plants as upon the eighteen sprayed plants.

Experiments with Lawn Grasses.

The nine border plots sown to lawn grasses last year have been kept closely cut with a lawn mower during the present season. Italian rye grass in Plot I. has proved the most rapid grower, and late in November had a lively green color not equaled by any other variety. The three poas in plots 5, 6 and 7 were nearly alike, and all of a healthy color. One of the best plots is No. 8, where Redtop has made a fine carpet, which, however, turns to a brown in late autumn. Plots 1, 2 and 3, the fescues, are the poorest in stand, No. 1 not holding its own and two and three are nearly alike in being

weedy. Plot 4, the Rhode Island bent grass, resembles the Redtop, but is not as good and takes on a straw color for autumn.

So far as the experiment has gone, the indications are that a good lawn would be produced by sowing a mixture of equal parts of Kentucky blue grass, Redtop and Italian rye grass.

EXPERIMENTS WITH BORDEAUX MIXTURE.

The Bordeaux * most generally employed the present season was prepared according to the following formula :

Copper sulphate (bluestone)	6 pounds.
Quicklime	4 pounds.
Water	60 gallons.

To dissolve the copper sulphate, it should be put in a bag of some coarse material and suspended so as to dip into water not more than two or three inches. Several pounds may be dissolved in this way within two or three hours, but if the entire quantity is at once immersed much more time will be required, and if the crystals of sulphate be thrown loosely into water a considerable proportion may remain undissolved in spite of long-continued stirring. It is well to suspend the bluestone in water over night, and thus avoid any possible delay in the following day's spraying. Treated as above recommended, one pound of copper will readily dissolve in one gallon of water. The solution of the copper may be greatly hastened by the use of hot water. Solutions of copper sulphate, as well as the prepared Bordeaux, should be contained only in wooden, "granite" or copper vessels.

Lime slakes more thoroughly in hot water than in cold, and after slaking it should be diluted to a thin whitewash and strained through coarse sacking to remove all sediment. Bordeaux prepared by pouring copper into lime has been found to remain in suspension longer than when lime is poured into copper, and if the copper is about half as dilute as the lime the effect is better still. If, for example, sixty gallons of Bordeaux are to be prepared, slowly pour a ten-gallon solution of the required copper into twenty gallons of lime-wash,

* Bordeaux prepared with lime is referred to in this report as "Bordeaux" simply, while the mixtures in which soda and potash are substitutes for lime are spoken of as "soda-Bordeaux" and "potash-Bordeaux" respectively.

stirring thoroughly; after which the concentrated Bordeaux thus formed may be diluted to sixty gallons.

The spraying at this Station has thus far been done with a five-gallon knapsack pump, which, for small areas, will be found most convenient. For spraying orchards, vineyards or entire fields a force-pump attached to a tank and mounted on wheels is necessary. Various sorts of spraying machinery may be obtained from a number of reliable firms throughout the country.

A limited use was also made of a Bordeaux in which scarcely more than enough of the lime was used to neutralize the acidity of the copper sulphate. This mixture, although still somewhat alkaline, has been referred to as "neutral" Bordeaux to distinguish it from the one in which twice as much lime was used. Its formula is as follows:

Copper sulphate	6 pounds.
Quicklime	2 pounds.
Water	60 gallons.

Bordeaux prepared according to the above formula has proved fully as effective a fungicide as that in which twice as much lime was used and the diminished coating of lime upon the foliage makes the neutral Bordeaux more desirable with which to treat ornamental plants.

In thus reducing the amount of lime, any liability of burning the foliage may be avoided by testing the mixture with a bit of red litmus paper, only a small supply of which is necessary and may be obtained at most drug stores. If the litmus when dipped in Bordeaux turns blue, the mixture is alkaline, and can be applied without danger; but if the color remains unchanged, more lime should be added until a blue color replaces the red of the test paper.

During the present season there has been less of fungous diseases upon the Experiment Area than formerly. For example, no blight or leaf spot has appeared to any extent upon the celery, spinach, onions, lima beans and peppers, and tomatoes and beans were less affected than usual.

Wherever there was an opportunity for the Bordeaux to show its fungicide power it has done good service. This is particularly true with the leaf spot of the beet, and anthracnose of the cucumber and bean, and the bacteriosis of the bean.

Experiments with Soda-Bordeaux.*

In the mixture termed soda-Bordeaux, caustic soda is used instead of lime, to neutralize the copper sulphate. The mixture was made as nearly neutral as possible by the use of red litmus paper, as previously recommended in the preparation of neutral Bordeaux.

The soda-Bordeaux thus made burned the foliage usually only slightly, and it is likely that it would have been improved by being somewhat alkaline. The formula is therefore withheld until further experiments determine the proper rates of the substances.

The advantage of pouring somewhat concentrated copper solution into dilute alkali holds equally well here as in the preparation of Bordeaux previously mentioned. A ten-pound can of the soda was sufficient for the season's spraying, the entire amount being dissolved at once, stored in a demijohn, and the small portion necessary to neutralize a pound of copper sulphate removed as needed for spraying.

"Lewis Lye." Soda-Bordeaux was also prepared the present season from a well-known brand of domestic soda, according to the following formula:

Lewis lye	1 can (14 ounces).
Copper sulphate	29 ounces.
Water	20 gallons.

"Babbitt's Potash or Lye." This brand of lye required for the neutral point the following formula:

Babbitt's potash or lye	1 can (17 ounces).
Copper sulphate	46 ounces.
Water	30 gallons.

The trials of these two commercial brands, while not extensive, demonstrated their value, and they have the merit of being put up in small quantities, subject to no appreciable variation in weight, and kept in stock, one or both, at almost any grocery.

*For a full account of this fungicide see the report for 1896, pages 362–366.

Experiments with Potash-Bordeaux.*

Potash-Bordeaux has been used upon the Experiment Area the present season to the same extent as the Bordeaux and soda-Bordeaux. In this mixture caustic potash was used in place of either lime or soda to neutralize the copper sulphate.

As a preventive of blight, potash-Bordeaux proved equal to either Bordeaux or soda-Bordeaux, but, like the latter, it burned the young foliage somewhat, of certain crops, the present season, indicating that an excess of the alkali may be better than when made at the neutral point or, possibly, slightly acid.

EXPERIMENTS WITH CUPRIC HYDRATE.

A modified form of soda-Bordeaux was used upon the Experiment Area to the same extent as the soda-Bordeaux proper, Bordeaux and potash-Bordeaux. This mixture consists of cupric hydrate, the precipitate in soda-Bordeaux, which is usually spoken of as "hydrate" elsewhere in this report. It is prepared by pouring off the clear liquid from well-settled soda-Bordeaux and washing the precipitate by adding more water. After adding and pouring off water a number of times it is finally dried and pulverized. This powder, suspended in water by stirring, and brought to the same strength as ordinary Bordeaux, was used for the first four sprayings, but for the remainder of the season the "hydrate" was made by using the washed precipitate without drying it.

As a fungicide, this mixture was found inferior to Bordeaux and the soda and potash-Bordeaux.

Table of Alkaline Values.

The following table gives the alkaline value—that is, the power to neutralize copper sulphate—of the leading brands of lye in small cans. The first in the list is a genuine potash that comes in twenty-pound cans, and the last is the crude potash, furnished in barrels. Also, for comparison, a comparatively pure soda is given second in the list. All other brands are known as pound cans, and sell for from

*A full account of this fungicide was given in the report for 1896, pages 367–370.

8 to 12 cents at retail, except the Natrona, which is a two-pound can, costing 20 cents.

The table shows the amount of copper sulphate required for any of the brands named, and the amount of standard Bordeaux each will produce:

	Gross weight of can.		Weight of substance.		Cop. sulphate required.		Amount mixture.	
Potash (Troy)	22.06	lbs.	21.06	lbs.	50	lbs.	500	gals.
Soda (Troy)	11.2	"	10.17	"	46.22	"	462	"
Lewis lye	14	oz.	11.15	oz.	2	"	20	"
Babbitt's potash	17	"	14.75	"	3	"	30	"
Champion	15.75	"	12	"	1.6	"	18	"
Red Seal	17	"	14.5	"	2.4	"	24	"
Leggett's	17	"	14.75	"	2.50	"	25	"
Lehman's	14.75	"	12.25	"	2.4	"	24	"
Hirsh	14.5	"	12.75	"	1.8	"	18	"
Washington	14.25	"	12.75	"	1.7	"	17	"
Saponifier (solid)	15.75	"	14.25	"	2.5	"	25	"
Saponifier (granulated)	17	"	14.75	"	2.6	"	26	"
Natrona	42.75	"	36.75	"	7.2	"	72	"
Barrel potash	5	lbs.	5	lbs.	8	"	80	"

EXPERIMENT IN SHADING.

With all the previously-described crops an experiment in shading has been carried out during the present season. The lower third of the cultural belt (No. 6) was usually employed for this test, thus giving an area of eleven by eleven feet. The shading was effected by placing frames of lath upon stakes being held in position by stout strings. Each lath-frame was four feet square, and made by nailing ordinary carpenter's laths to laths at their ends, with a single lath interwoven across through the middle. The vacant space between the laths was equal to the width of the lath, so that the actual amount of shading is half that of total and may be spoken of as half-shading. Sixteen two-inch stakes were driven into the ground so that each of the nine frames would rest upon stakes at all four corners. To accommodate them a cap of inch board six by six inches square was nailed upon the top of each stake. The height at which the shading was placed above the soil was determined by the natural stature of the plants to be grown under them. Thus, with dwarf peas, the distance was about fifteen inches, and with potatoes, tomatoes, egg-plants and beets the height was double that for peas and cucumbers. Figure 2 gives the general appearance of the shades.

This shading was put in position as soon as the seed had been sown, it being desired to note any differences that might follow in the germination of the seeds as well as the after-growth of the plants.

The influence of the shade was noted with some crops from the outset, the time of the appearing of the plants being different under the laths than in the open.

For example, upon May 28th the lima beans were everywhere up in their plot, except under the shade, where they failed almost en-

Fig. 32.
Conditions of Lima Beans Under Shade after the Second Planting.

tirely. The reason for this is doubtless somewhat complex, but a lower temperature in the shaded portion is not the least part of it.

Lima beans, it was shown by this test with shading, are extremely sensitive, and it is not unlikely that they often fail because the soil is too cool, and possibly too wet also for them. The seed and the seedsmen are often charged with failure, when the trouble is with the soil and the sower.

A second crop of lima beans was planted, and then the results were reversed, the seeds starting much sooner in the shade than elsewhere. The condition of this experiment is shown in Figure 32. Those in the sun were so long delayed in appearing that it was a source of wonder; those under the shade being in their full first leaves long before those in the open appeared above ground. The conditions with this crop were quite the reverse of the first, and the moist, warm, shaded soil was more congenial for growth than the dry, hot earth in the full midsummer sun.

The notes made upon the wax beans for May 26th run as follows: The shade was removed from the wax beans (Plot I., Series V.) and the ground cultivated. Upon an average, the plants throughout the plot were six inches high, and beginning to show well the first of the trifoliate leaves.

Three persons who were present were impressed with the darker green of the foliage of the plants growing under the screen, and that the leaves were larger and the third leaf much less advanced. The stems were somewhat shorter in the shaded plants.

Aside from the smaller size of the shaded plants and their larger first pair of leaves and the smaller third leaf and darker green color above noted, it was observed that the shaded plants had much fewer tubercles upon the roots than those grown in the full sunlight. There was no other difference to be noted in the subterranean portions of the plants.

The following is condensed from the observations upon the turnips: The leaves have a darker green color, are less blighted and have less hairiness in the shade than in the open. The roots are considerably smaller under the lath than elsewhere, and no influence is observed upon the amount of club-root.

The chief difference with potatoes was the weaker growth of vine, which kept free from the Phytophthora longer than the unshaded plants. The tubers were small and the scab apparently uninfluenced.

Onions showed no marked effects in any way by the shade.

Peas, in the time of appearing above ground, gave the following results for the first crop, the observations being recorded upon April 22d: Under the shade 33 pea plants were breaking ground, while an equal area in the sun showed 212 plants. In this case the soil of early Spring needed the full exposure to the sun to give the heat required by the peas for their germination.

There was but little difference in the growth of the vines in the shade, they being somewhat higher and produced fewer pods than the plants in the sun.

The second crop sown in midsummer did not furnish any contrast in the germination, but here the shaded plants were less fruitful, as well as less blighted than the unshaded ones.

The carrots in the shade produced foliage that was more extensive than in the full sunlight, but the roots were much smaller. Here, again, the blight was apparently kept off to some extent by the shading.

Fig. 33
Relative Size of Shaded and Unshaded Lettuce.

There were at least four crops that were improved by the shading, so far as increase of substance and its quality are concerned.

Lettuce in the spring crop did not show this advantage in particular, but with the second crop the following notes were made on September 9th: There is great difference in the growth of the lettuce in the shade and sun, it being much better in the former condition than in the latter. Figure 33 shows the relatively greater size of the

shaded plants. From the experience of the first crop, it was expected that there would be good results from shading in midsummer sowing. The weather was such as to favor the fully-exposed seed and seedlings, as almost daily rains prevailed throughout the last half of July and the first week of August, and cool days were the rule all through the month of August. Had there been the usual weather of midsummer, a small amount of rainfall and a high temperature, the plants

Fig. 34.
Relative Size of Shaded and Unshaded Spinach.

fully exposed upon our gravelly soil would scarcely have amounted to anything, and while the shaded plants might have been smaller than at present, the results would have probably been greater than now.

The showing during the present unusual season is greatly in favor of the use of some shade to take off the keen edge of the hot sun from the delicate foliage of the lettuce. The experiment teaches that midsummer lettuce can be grown with ease under adverse circumstances

of season and soil, provided shading is used for a protection as above described.

Spinach was favored by the shade and the size and good quality considerably increased thereby, as shown in Figure 34, where two varieties are shown, the larger being the shaded in each case. Swiss

Fig. 35.
Relative Size of Shaded and Unshaded Swiss Chard.

Chard is another kind of plant that prefers the half shade, as the records show in actual crop, as illustrated in Figure 35. It should be noted here also that the leaf blight was much less abundant upon the shaded than upon the fully-exposed plants.

The crop above all others that was most influenced by shade, was the celery. Six varieties were tested in this way, and all grew to

more than double the size of other plants of the same lot that were in the full sun, but later in the season, with shorter days and less light, the exposed plants overtook and surpassed the shaded ones. Figure

Fig. 36.
Relative Size of Shaded and Unshaded Celery.

36 shows the marked difference in size of an average plant from the shaded and exposed areas in September.

Notes upon Shading Bush Beans.

The shaded bush beans were harvested upon July 23d. At this time three of the six varieties, namely, Currie's Rust-proof (row 2), Golden Wax (row 4) and Early Refugee (row 5), were fully matured in the open, and the leaves with but few exceptions were fallen, and the pods practically mature.

The following are the figures obtained at the harvest of the shaded beans and the crop upon the adjoining equal area :

	Vines.	Pods.	Green pods.	Ripe.	Green leaflets.
Sun (1)	1.66	.50	56	70	210
" (2)	1.16	.38	...	84	40
" (3)	2.66	.66	10	108	280
" (4)	1	.36	2	110	10
" (5)	.94	.30	...	87	12
" (6)	2.75	.60	35	65	310
Total	10.17	2.80	103	524	862
Shade (1)	1.40	.75	91	41	186
" (2)	1.12	.50	30	81	83
" (3)	2.50	.72	37	68	345
" (4)	1	.42	17	85	35
" (5)	.75	.50	13	97	29
" (6)	1.75	.81	99	60	297
Total	8.52	3.70	287	432	975

The weight of the whole crop of vines and pods is seen to be somewhat greater for the plants in the full sun than in the shade, that is, 10.17 pounds for the former to 8.52 pounds for the latter. The weight of pods is reversed, being 2.80 pounds for the sun to 3.75 pounds for the shade, a difference that is accounted for in the next two columns of the table.

There are only 103 green pods from the plants in the sun to 287 from the shade, while the ripe ones were 524 and 432 respectively for the same areas. In other words there were five times as many ripe as green pods in the sun, while not twice as many in the shade. The total number of pods is nearly the same for the two areas, namely, 627 for the sun and 719 for the shade. But as some of the latter are necessarily young, the actual crops of seeds in the two instances may be considered equal.

The condition of foliage is fairly shown by the number of green leaflets, and in this there is not a great difference. The late varieties

held the foliage in both cases about equally; but of the three early sorts the shaded showed much more green, and this is the better test of the influence of the shade. The total leaflets of the matured sorts in the sun is 62 against 147 in the shade.

From this single experiment it is gathered that the half-shading of bush beans for the spring crop, under the conditions that obtained in New Jersey in 1897, is not disadvantageous. While there is somewhat less growth of vines, the pods are more numerous under the shade than in the full sun, and not the least is the prolonged period when the crop is green and suitable for the table.

The primary object of the experiment, namely, the study of the influence of shade upon the development of fungi, was thwarted, in that the blights were almost entirely absent from the crop.

The same plot was in beans for a second crop, and the plants under the shade kept a close pace with those outside. They were a trifle later in coming into bloom; were somewhat shorter, but this was more in appearance than reality, for the petioles did not bend upward and tilt their leaflets so high as those in the full sun. A very striking difference was in the shade of green, it being decidedly darker under the lath than in the open. The sun, while producing the leaf green, also has the power of bleaching when it falls unbroken during midsummer. There were fewer and larger leaflets in the shade, and what with them held out nearly flat and of a deeper green color there was quite a contrast between the shaded and fully-exposed plants.

This belt of beans was left unharvested to note the effect of frosts, which came somewhat before the seeds were fully matured. For the first few frosts the plants under the shade were untouched, remaining green and in full leaf after the others were bare stems. The shade prolonged the growing-season.

Difference in the Appearance of the Plants.

There was usually a difference in the size of the plants in the shade from those in the open. The turnip plants were somewhat larger but the roots did not develop well. Beets in the shade likewise were larger. Spinach was fully twice as large in the shade as in the open ground. Lettuce likewise was favored by the shade, and the plants began to send up the flower stalk sooner in the shade than the sun. There was no great difference in beans, peas, tomatoes and potatoes. Egg-plants were smaller. The most striking increase in size was with celery.

Differences Other than Size.

One striking peculiarity of the shaded plants was the darker green of the foliage shown in lettuce, turnips and beans in particular, but most of all in the beans.

Together with this difference in color was a noticeable increase in

Fig. 37.

Shows the Greater Density of Pea Foliage (a) when Grown in the Full Sun.

the leaf surface of the individual leaves over those in the open. For example, the bean leaflets were fully a third larger in the shade than in the sun. Turnips and beets showed the same, which fact is covered by the previous statement concerning the increase in size of those plants when in the shade.

The carrots offered a good illustration of the striving after greater leaf surface, for in this crop the leaves are finely dissected and almost reduced to the veins of the leaves. Here there was a widening of all the narrow parts, some of them being nearly double the ordinary width.

Another difference noted by microscopic measurements was the diminished thickness of the shaded foliage. A satisfactory method of obtaining a comparison between the thickness of the leaves of plants grown in shade as against those in the sun is obtained by making sun prints of the two sets of leaves. When exposed to the sun for the same length of time before photographic paper, the leaves from the shade invariably give a deeper print than those from the open ground, thus showing that the leaves grown in the shade are either thinner or more easily penetrated by the sun's rays, or both. Figure 37 shows the corresponding foliage from an unshaded (*a*) and shaded (*b*) pea plant.

The Influence of Half Shade Upon the Soil.

In studying the effects of the shade experiments upon the crops and the prevalence of fungous enemies, one may forget the soil and the action that takes place in it when shade is employed.

Recently the crop of turnips was harvested, and the soil examined under the shade and in the sun. In like manner the spring crop of lettuce was removed (July 10th) and the soil of belt 6 prepared for a second crop. There had been a drought of fully two weeks, and upon spading the soil it was found moist under the shade, while elsewhere it was very dry and forked with difficulty. The shading acts as a mulch and keeps the soil near the surface in much better condition than where the full sun falls upon it.

Influence of Half Shade Upon Temperature.

A daily record was kept of the temperature of the air under the shade and in the open, the thermometers in each case being one foot above the soil. In monthly averages the shaded was cooler than the exposed air by the following differences: For May, 4°; June, 4.2°; July, 6.5°; August, 7.7°; September, 11.6°. It is to be noted that the difference increased as the season advanced. The actual extremes ranged from zero upon some rainy days to 21° in the hottest clear weather.

EXPERIMENT IN INFECTING SOIL WITH THE POTATO SCAB FUNGUS.

Outside of the Experiment Area and elsewhere upon the College Farm a piece of ground was secured that had not been in potatoes for many years. This strip was of the same width (eleven feet) as each and all of the belts in the Experiment Area and extended lengthwise for one hundred and sixty-five feet. It was divided into ten equal plots, eleven by sixteen and a half feet, and each one was, therefore, one-half the size of the belts in the Experiment Area.

Eight bushels of badly-scabbed potatoes (Early Rose) from the Experiment Area were used in this experiment, two of them being applied unchanged, two after being steam-heated, and four were fed to young cattle and the manure carefully saved and employed in ways as outlined in the plan below:

Plot 1. One bushel of scabbed potatoes spaded in, September, 1896.

Plot 2. One bushel of scabbed potatoes heated twenty minutes with steam and spaded in, September, 1896.

Plot 3. Check.

Plot 4. One bushel of scabbed potatoes applied to surface, September, 1896.

Plot 5. One bushel of scabbed potatoes heated (as in 2) and applied to surface, September, 1896.

Plot 6. One bushel of scabbed potatoes fed to young cattle, and the manure kept in a box in the manure cellar and applied to surface after planting, April, 1897.

Plot 7. One bushel of scabbed potatoes fed (as in 6), and kept (as in 6) and applied previous to planting, April, 1897.

Plot 8. Check.

Plot 9. One bushel of scabbed potatoes fed (as in 6), and manure applied to surface, September, 1896, and spaded in previous to planting, April, 1897.

Plot 10. One bushel of scabbed potatoes fed (as in 6), and manure spaded in, September, 1896.

The potatoes were planted April 24th, 1897, there being three varieties used, namely, "American Giant," "Rural No. 2," and "Early Rose." There was one row of each variety running continuously through the whole length of the strip, and ten pieces of each sort used in each of the ten plots.

All the plots were treated alike as regards cultivation, and upon September 11th the crop was harvested, row by row, in each plot, and counts, weights in ounces, and percentages taken, as shown in the following table:

Plot 1.

	E. Rose.	Rural.	Am. Giant.	Total.
Number of plants	7	10	9	26
Weight of plants	10 ounces.	7 ounces.	9 ounces.	22 ounces.
Weight scabbed potatoes	36 "	84 "	36 "	156 "
Weight smooth potatoes	8 "	28 "	28 "	64 "
Per cent. of scab	48	61	23	44*
Number rotten	...	...	...	...

Plot 2.

	E. Rose.	Rural.	Am. Giant.	Total.
Number of plants	7	9	9	25
Weight of plants	10 ounces.	15 ounces.	6 ounces.	31 ounces.
Weight scabbed potatoes	52 "	116 "	28 "	196 "
Weight smooth potatoes	24 "	28 "	44 "	96 "
Per cent. of scab	45	58	23	41
Number rotten	...	...	...	...

Plot 3.

	E. Rose.	Rural.	Am. Giant.	Total.
Number of plants	6	9	10	25
Weight of plants	20 ounces.	11 ounces.	7 ounces.	38 ounces.
Weight scabbed potatoes	16 "	20 "	12 "	48 "
Weight smooth potatoes	12 "	64 "	36 "	112 "
Per cent. of scab	20	5	3	9
Number rotten	7	5	3	15

Plot 4.

	E Rose.	Rural.	Am. Giant.	Total.
Number of plants	8	10	10	28
Weight of plants	12 ounces.	20 ounces.	4 ounces.	36 ounces.
Weight scabbed potatoes	60 "	24 "	28 "	112 "
Weight smooth potatoes	36 "	48 "	16 "	100 "
Per cent. of scab	30	13	40	28
Number rotten	...	3	...	3

Plot 5.

	E. Rose.	Rural.	Am. Giant.	Total.
Number of plants	6	9	9	22
Weight of plants	4 ounces	12 ounces.	2 ounces.	18 ounces.
Weight scabbed potatoes	8 "	30 "	... "	38 "
Weight smooth potatoes	52 "	52 "	32 "	136 "
Per cent. of scab	8	40	4	17
Number rotten	3	9	...	12

* Average.

Plot 6.

	E. Rose.	Rural.	Am. Giant.	Total.
Number of plants	8	10	5	23
Weight of plants	6 ounces.	8 ounces.	10 ounces.	24 ounces.
Weight scabbed potatoes	... "	4 "	8 "	12 "
Weight smooth potatoes	44 "	52 "	20 "	114 "
Per cent. of scab	...	2	6	3
Number rotten	14	21	...	35

Plot 7.

	E. Rose.	Rural.	Am. Giant.	Total.
Number of plants	9	9	10	28
Weight of plants	12 ounces.	1 ounces.	5 ounces.	18 ounces.
Weight scabbed potatoes	... "	44 "	24 "	68 "
Weight smooth potatoes	80 "	36 "	96 "	212 "
Per cent. of scab	...	30	15	15
Number rotten	9	6	...	15

Plot 8.

	E. Rose.	Rural.	Am. Giant.	Total.
Number of plants	8	9	10	27
Weight of plants	22 ounces.	13 ounces.	3 ounces.	38 ounces.
Weight scabbed potatoes	... "	20 "	16 "	36 "
Weight smooth potatoes	36 "	40 "	36 "	112 "
Per cent. of scab	...	6	10	5
Number rotten	...	...	...	...

Plot 9.

	E. Rose.	Rural.	Am. Giant.	Total.
Number of plants	9	10	8	27
Weight of plants	8 ounces.	11 ounces.	7 ounces.	26 ounces.
Weight scabbed potatoes	8 "	36 "	3 "	47 "
Weight smooth potatoes	64 "	60 "	36 "	180 "
Per cent. of scab	4	20	1	8
Number rotten	...	1	...	1

Plot 10.

	E. Rose.	Rural.	Am. Giant.	Total.
Number of plants	7	8	9	24
Weight of plants	4 ounces.	7 ounces.	3 ounces.	14 ounces.
Weight scabbed potatoes	2 "	20 "	... "	22 "
Weight smooth potatoes	20 "	44 "	68 "	132 "
Per cent. of scab	2	10	...	4
Number rotten	2	...	1	3

	Plot 1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Number of plants	25	25	25	28	22	23	28	27	27	24
Weight of plants	23	31	38	36	18	24	18	38	26	14
Weight of scabbed potatoes	156	196	48	112	38	12	68	36	47	22
Weight of sound potatoes	64	96	112	100	136	114	212	112	180	132
Per cent. of scab	44	41	9	28	17	3	15	5	8	4
Number rotten	...	...	15	3	12	36	15	...	1	3

The scab is greatest (44 per cent.) in Plot 1, where the scabbed potatoes untreated were spaded in in September, followed closely by Plot 2 (41 per cent.), where the potatoes were steam-heated and spaded in in September. The next highest (28 per cent.) is where the scabbed potatoes untreated were left upon the surface through the winter, and the next plot (17 per cent.) is No. 5, where the potatoes were steam-heated and applied to the surface of the soil. The average per cent. of scab upon the four plots receiving the potatoes is 32 per cent., while that upon the check is only 9 per cent.

The scab upon the plots receiving the manure made from the scabbed potatoes is very small, the largest amount, 15 per cent., being upon Plot 7, where the application was made in April, just previous to planting, and the next largest, 8 per cent., in Plot 9, where the manure from scabbed potatoes was applied to the surface in September and spaded in in April, just previous to planting. These two plots had about double the amount of scab that was produced upon the check plot separating them in the series.

Plot 6, where the manure was applied to the surface after planting, gave less scab (3 per cent.) than the check (5 per cent.), and Plot 10, where the manure was spaded into the soil in September, gave only 4 per cent.

It would seem from this single test that the application of scabby potatoes to land was hazardous, as it may greatly increase the scab in the crop of potatoes that follows. It also shows that this danger is much increased by mixing the scabby potatoes with the soil, there being nearly double the amount upon the plots where the potatoes were spaded in as compared with those similarly treated and left upon the surface.

The experiment goes to show that the steam-heating of the potatoes for twenty minutes diminishes to a small extent only (as from 72 to 58) the capacity of the potatoes to contaminate a soil to which they may be added.

A point of perhaps the greatest interest is that of the almost entire absence of the scab where the infested potatoes are fed to cattle and the manure is placed upon land where potatoes are to be grown. The experiment indicates that there may be no danger in disposing of scabby potatoes in this manner.

Additional Experiment with the Scab Fungus.

Three belts in Series II. were set aside the present season for the growing of wild and cultivated plants the roots of which, it was thought, might be subject to the scab disease of the potato.

In belt 4 of Plot II. it was designed to grow nine species belonging to the same family as the potatoes. The list was as follows: *Petunia* (cult.), *Physalis Franchatti Atropa Belladonna* L., *Solanum Carolinense* L., *Solanum Dulcamara* L., *Datura Stramonium* L., tomato, pepper and tobacco. Plants were obtained of only the last four species in the above list, and the roots of these seemed wholly free from scab.

Belt 1 of Plot III. was planted with seeds of the following large-rooted weeds: *Malva rotundifolia* L., *Onagra biennis* (L.), *Daucus carota* L., *Pastinica sativa* L., *Dipsacus sylvestris* Huds., *Arctium Lappa* L., *Cynoglossum officinale* L., *Echium vulgare* L., *Verbascum Thapsis* L. and *Rumex crispus* L. *Malva rotundifolia* L., *Daucus carota* L., *Arctium Lappa* L., *Echium vulgare* L. and *Rumex crispus* L. were the only members of this list of which specimens were obtained. Their roots were thoroughly examined, but no indication of scab was detected.

In the sixth belt of Plot III. five varieties of sweet potatoes were grown. Although there was 75 per cent. of scabbiness upon the Irish potatoes grown upon the same area in 1896, no indication of the disease was manifest upon this year's crop of sweets.

The fourth belt in Plot IV. was devoted to plants which are grown as root-crops. Here were planted artichokes, chufas, cardoon, chickory, dandelion, salsify, parsnip and six varieties of radishes. With the exception of the dandelion, which failed to grow, there was an abundance of all the above-mentioned plants. All six varieties of radish were attacked by scab, and the late sorts were considerably disfigured by the time they were large enough for market. Upon the remainder of the crops represented in this belt the scab seemed to be entirely absent.

INFLUENCE OF DROUGHT UPON VEGETATION.

Although the year 1897 has a record for remarkably excessive rains for July, there have been three periods of drought during the growing-season, namely, from April 18th to 25th, July 3d to 11th, before the heavy rains began, and September 3d to 16th, following the downpour that lasted fifteen days.

From July 9th to 13th the following notes were taken of the condition of the crops in the Experiment Area:

The dry spell was broken by heavy rains which fell upon July 13th and 14th. The various crops upon the Experiment Area suffered differently from the lack of water, and behaved in various ways under the trying condition of the drought.

The spinach was the greatest sufferer, for it had just passed into the flowering period. The thin, succulent leaves dried up and became dead, leaving the stalks bare of green. That it was the hot sun and dry air was evident from the much better health of the plants that were under the half shade.

The next worse plant in the drought was the lettuce, the hot sun scalding the foliage, which was followed closely by various fungi and a rot of the heads. Under the shade the leaves were kept from injury and the plants retained their freshness until the crop was harvested.

Peas of the American Wonder sort were in bearing as the drought came, and it hastened their ripening, while the foliage became a victim to the blight *Ascochyta Pisi* Lib. Here, again, the shade prolonged the time of green peas for fully ten days.

Beans of the bush sorts were matured with great rapidity and the leaves fell from the stems, leaving the pods nearly bare long before they were ripe. Some sorts held the foliage better than others, notably the "Green Flagolet," which showed the bacterial blight considerably, but retained the leaves. Under the shade the leaves were larger than elsewhere and of a bright green color, while in the sun they were yellow or fallen from the plants.

Limas did not suffer materially from the drought.

Cucumbers made a short growth of vines, blossomed profusely, but the setting of fruit was small. The plants under the shade thrived much better than those in the full sun.

Potatoes produced not over half of the usual growth of stems and leaves, and these turned yellow and brown, indicative of a short crop.

The other three solanaceous crops, namely, egg-plants, tomatoes and peppers, thrived well under the prevailing dry conditions, and there was but little gain of the shaded over the unshaded plants.

Onions suffered severely, and there was no apparent advantage in shading.

Cabbage did not suffer much.

Turnips were badly dried up in foliage by the lack of water, and the plants under the shade kept fresh with increased development of leaves.

Beets wilted early in the day and remained in a drooping condition until revived the following night. The shade favored the plants, as shown by their larger size.

Carrots were in a comparatively moist place and did not feel the drought. The shaded plants were somewhat larger in foliage, however, than elsewhere.

Radishes wilted badly.

Of the five classes of beets, namely, "Long Smooth Blood-red," "Swiss Chard," "Long Red Mangel," "White Sugar" and "Early Yellow Turnip," the chard was much more wilted than any of the others. The tips of the leaves of nearly all the beets in the weed belt were more or less declined at three o'clock P. M., but those of the Swiss Chard were quite generally horizontal or resting upon the neighboring weeds.

The Swiss Chard has much larger blades than any other of the beets represented in the belt, and therefore exposes a greater surface to the drying action of the sun and atmosphere. Thinking that the root system might be smaller than in ordinary beets, because the chard is grown for its foliage and does not produce a large root, sample plants of it and of the Long Red Mangel were removed from the soil, when it was found that at this stage in the growth of the beets the Swiss Chard had much larger and longer tap roots and more lateral roots than the mangel.

It seems quite evident that there is nothing below ground that will account for the greater wilting of the chard.

It was suggested that the mesophyll of the leaf might be thinner in the chard, and thereby it would be less able to remain turgid when water was in demand; but a microscopic study of leaf sections shows that the chard has a thicker leaf than the mangel, and we must seek further for the cause of the wilting. This seems to be in the shape

of the petiole and the way the leaves stand as ordinarily growing. The chard has a broad petiole where it joins the stem, averaging fully an inch in the beets pulled up June 28th. With this shaped petiole and the concave surface inner and uppermost, the leaf naturally hangs outward. The large blades add to the natural tendency to bend, and whenever there is a lack of moisture the foliage of this plant bends downward.

The mangel has smaller blades, with the petioles more nearly upright, and the transection is more nearly that of the cylinder. The strands of fibers are so disposed as to hold the leaf upright.

Ornamentals.

Hollyhocks were the most affected by the drought, losing their leaves for one-third of the stem from the bottom.

Sweet peas came next, and depths of planting did not make much difference, except those one inch deep, which suffered most.

Nasturtiums wilted badly, and flowers had less color during the drought.

Mignonette and pinks showed no effect, and dahlias, cannas, gladiolus, ampelopsis, hibiscus, cercis and pæonia, were all right.

EXPERIMENTS WITH SWEET POTATOES.

In 1895 experiments were made with sweet potatoes upon the farm of Mr. George W. Jessup, Cinnaminson, N. J., for the purpose of finding some preventive of the soil rot.* There were six series of plots in the field, three of them receiving fertilizers, namely, lime, manure and kainit, and three others, alternating with these, which received chemicals that it was hoped might check the soil rot, namely, sulphur, corrosive sublimate and copper sulphate. The arrangement of the experiment offered an opportunity for combining the materials in pairs and for leaving sufficient check plots. The accompanying plan (Figure 38) shows the whole arrangement, and from it it will be seen that the first plot to the left, in each series, receiving the largest amounts of the substance; the middle row of plots (up and down) half these amounts, respectively, and a quarter as much was applied

* For a consideration of this disease and engravings showing the trouble, the reader is referred to Bulletin No. 112, and the Annual Reports for 1895, pages 276–283, and 1896, pages 319–327.

Series	Year	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
Series I. Lime.		Slaked lime, 1,000 bushels.	Check.	Lime, 500 bushels	Sulphur, 625 pounds.	Lime, 250 bushels.
	1895	Stand, 80 per cent. Yield, 19 pounds clean ; 21 pounds marked	Stand, 63 per cent. Yield, 17 pounds clean ; 22 pounds marked.	Stand, 75 per cent. Yield, 28 pounds clean ; 21 pounds marked.	Stand, 65 per cent. Yield 25 pounds clean ; 12 pounds marked.	Stand, 98 per cent. Yield, 25 pounds clean ; 18 pounds marked.
	1896	Stand, 40 per cent. Yield, 5 pounds clean ; 65 pounds marked	Stand, 90 per cent. Yield, 50 pounds clean ; 7. pounds marked.	Stand, 55 per cent. Yield, 30 pounds clean ; 59 pounds marked	Stand, 75 per cent. Yield, 41 pounds clean ; 65 pounds marked	Stand, 95 per cent. Yield, 40 pounds clean ; 110 pounds marked
Series II. Flowers of sulphur.		Sulphur, 2,500 pounds.	Lime, 500 bushels ; sulphur, 1,250 pounds.	Sulphur, 1,250 pounds.	Check.	Sulphur, 625 pounds.
	1895	Stand, 55 per cent. Yield, 47 pounds clean ; 17 pounds marked	Stand, 15 per cent. Yield, 4 pounds clean ; 5½ pounds marked.	Stand 70 per cent Yield, 51 pounds clean ; 11 pounds marked	Stand, 60 per cent Yield, 5 pounds clean ; 49 pounds marked.	Stand, 94 per cent. Yield, 65 pounds clean ; 38 pounds marked
	1896	Stand 98 per cent Yield, 81 pounds clean ; 7 pounds marked.	Stand 60 per cent. Yield, 18 pounds clean ; 61 pounds marked.	Stand, 98 per cent. Yield, 110 pounds clean ; 50 pounds marked.	Stand, 98 per cent Yield, 70 pounds clean ; 70 pounds marked.	Stand, 98 per cent. Yield, 130 pounds clean ; 46 pounds marked.
Series III. Manure		Manure, 11 tons	Check.	Manure, half amount.	Manure half amount ; corrosive sublimate 50 pounds.	Manure, quarter amount.
	1895	Stand, 30 per cent. Yield, 1 pound clean , 12 pounds marked	Stand, 39 per cent. Yield, 1 pound clean ; 16 pounds marked.	Stand, 58 per cent Yield, 9 pounds clean ; 31 pounds marked.	Stand, 55 per cent. Yield, 5 pounds clean ; 32 pounds marked.	Stand 60 per cent. Yield 2½ pounds clean ; 32 pounds marked
	1896	Stand 90 per cent Yield, 50 pounds clean ; 57 pounds marked	Stand, 80 per cent Yield, 45 pounds clean ; 83 pounds marked.	Stand, 90 per cent. Yield, 87 pounds clean ; 65 pounds marked.	Stand, 95 per cent Yield, 80 pounds clean ; 46 pounds marked.	Stand, 98 per cent Yield, 129 pounds clean ; 40 pounds marked
Series IV. Corrosive sublimate.		Corrosive sublimate, 200 pounds.	Manure half amount ; corrosive sublimate, 100 pounds.	Corrosive sublimate, 100 pounds.	Check	Corrosive sublimate, 50 pounds
	1895	Stand, 100 per cent. Yield, 57 pounds clean ; 29 pounds marked.	Stand, 85 per cent. Yield, 31 pounds clean . 28 pounds marked	Stand, 80 per cent. Yield, 61 pounds clean ; 29 pounds marked	Stand, 55 per cent. Yield, 13 pounds clean ; 35 pounds marked.	Stand, 72 per cent Yield, 29 pounds clean ; 41 pounds marked.
	1896	Stand, 99 per cent Yield, 79 pounds clean ; 50 pounds marked	Stand, 98 per cent Yield, 45 pounds clean ; 123 pounds marked	Stand 98 per cent. Yield, 102 pounds clean ; 64 pounds marked.	Stand, 95 per cent Yield, 56 pounds clean ; 69 pounds marked.	Stand, 98 per cent. Yield, 68 pounds clean ; 102 pounds marked.
Series V. Kainit		Kainit, 5,000 pounds.	Check	Kainit, 2,500 pounds.	Kainit, 1,250 pounds, Sulphate of copper, 125 pounds	Kainit, 1,250 pounds.
	1895	Stand, 30 per cent. Yield, 9 pounds clean ; 16 pounds marked	Stand, 80 per cent. Yield, 19 pounds clean . 40 pounds marked .	Stand, 70 per cent. Yield, 10 pounds clean ; 35 pounds marked.	Stand, 40 per cent. Yield, 4 pounds clean ; 27 pounds marked.	Stand, 40 per cent. Yield, 5 pounds clean ; 28 pounds marked.
	1896	Stand, 85 per cent Yield, 45 pounds clean ; 62 pounds marked	Stand, 95 per cent. Yield, 43 pounds clean ; 69 pounds marked	Stand, 95 per cent. Yield, 81 pounds clean ; 60 pounds marked	Stand, 85 per cent. Yield, 91 pounds clean ; 52 pounds marked.	Stand, 90 per cent. Yield, 114 pounds clean ; 36 pounds marked.
Series VI Sulphate of copper		Sulphate of copper, 500 pounds	Kainit, 2,500 pounds ; sulphate of copper, 250 pounds.	Sulphate of copper, 250 pounds.	Check.	Sulphate of copper, 125 pounds.
	1895	Stand, 60 per cent. Yield, 24 pounds clean ; 23 pounds marked.	Stand, 75 per cent. Yield, 30 pounds clean ; 33 pounds marked.	Stand, 63 per cent. Yield, 12 pounds clean ; 50 pounds marked.	Stand, 10 per cent. Yield, none clean ; 15 pounds marked	Stand, 45 per cent. Yield, 15 pounds clean ; 36 pounds marked.
	1895	Stand, 90 per cent. Yield, 60 pounds clean ; 19 pounds marked.	Stand, 98 per cent. Yield, 94 pounds clean ; 66 pounds marked.	Stand, 95 per cent. Yield, 54 pounds clean ; 69 pounds marked.	Stand, 80 per cent. Yield, 22 pounds clean ; 57 pounds marked.	Stand, 95 per cent Yield 75 pounds clean ; 55 pounds marked

Fig. 38.

Plan and Results of Field Experiments for Soil Rot of Sweet Potatoes at Cinnaminson in 1895 and 1896.

to the corresponding plots at the right end in each series. Combinations were made between half amounts in the row of plots lying between full and half amounts, and quarter amounts were in combination in the plots lying between the half and quarter amounts. In Series I. the amount of lime was large—a thousand bushels per acre in the left-hand plot.†

The potatoes at harvesting were all inspected and assorted into those marked with soil rot and those that were clean. No other form of rot was present in sufficient amount to enter into the problem.

The following table of averages was constructed, followed by averages of combinations, shown by the figures opposite the braces:

	Pounds of Clean Roots.	Pounds of Marked Roots.	Clean.	Marked.
Lime..................	25	21	15	8
Sulphur..................	55	22		
Manure..................	4	25	18	30
Corrosive sublimate.....	49	32		
Kainit..................	8	26	17	30
Sulphate of copper.......	18	40		
Check..................	9	29		

Two of the six series, namely, manure and kainit, gave poorer results than the plot where nothing was used. Sulphur gave the highest yield of clean roots, followed closely by corrosive sublimate. While the figures do not differ greatly, there are factors not to be stated by them; for example, the potatoes from the sulphur plots were very smooth and fair, free from scurf, crooks and disfigurements, while quite the opposite was true of those from the corrosive sublimate belts. Further, the cost of sulphur was half that of the corrosive sublimate, to say nothing of the intensely poisonous and therefore dangerous nature of the latter substance.

Experiments with Sweet Potatoes in 1896.

The field of Mr. Jessup, outlined above, was continued in sweet potatoes in 1896, this making the third successive crop attempted upon the land. The whole area was fertilized uniformly throughout

†A young pear orchard had been set upon the land, and the size and shape of the plots were modified thereby, each being one-fiftieth instead of one-thirtieth of an acre, as in the original plan. The materials to be used had been purchased and parceled out, so that the amounts in all plots were larger than originally contemplated

with eight tons of stable manure and 500 pounds of complete fertilizer per acre, and no other additions were made to any plot, the point being to determine the lasting effects of the various substances that had been applied the previous year.

From the accompanying plan of results (Figure 38) some points of interest may be drawn. The season was a fair one as regards rainfall, and the crop was much larger than the previous year. There was, however, a decrease in the stand upon some of the plots, this being confined quite closely to those receiving the larger amounts of lime.

Sulphur had no material effect upon the growth of the vines, the stand being 98 per cent. in all the three plots, and, in short, in all the six series, excepting lime, the treated plots averaged in the stand of plants as high as their checks.

The table of averages of clean and marked roots, constructed to correspond with that made for the previous year, is as follows:

	Pounds of Clean Roots.	Pounds of Marked Roots.	Clean.	Marked.
Lime	25	75	31.5	63
Sulphur	107	34		
Manure	89	54	63	83
Corrosive sublimate	83	72		
Kainit	80	79	94	59
Sulphate of copper	63	48		
Check	48	69		

This table shows two things at the first glance, namely, that lime is not a preventive of the soil rot, and that of all the substances tested, sulphur is the best remedy for the disease.

During 1896, three other fields were under experimentation with sulphur for the soil rot. Two of them were in duplicate, located upon the adjoining farms of Mr. George W. Jessup and Mr. William Schmierer, Cinnaminson, N. J. The plan of the experiment was to apply sulphur in the row before setting the plants, in amounts ranging from 50 pounds to as high as 400 pounds per acre. The plots were four rows wide and sixteen rods long, each plot representing one-tenth of an acre.

Putting the results of the two experiments together, the following figures are obtained:

	Clean Roots.	Marked Roots.
Sulphur, 50 pounds per acre	625	850
Check	700	750
Sulphur, 100 pounds per acre	1,175	731
Check	1,250	581
Sulphur, 200 pounds per acre	1,325	550
Check	1,200	512
Sulphur, 400 pounds per acre	1,600	350

A study of this last set of figures leads to the conclusion that the yield of clean roots increases with the increase of the amount of sulphur, namely, 625, 1,175, 1,325 and 1,600 pounds. On the other hand, the decrease of marked roots is constantly and uniformly in the same direction, namely, from 850, 731, 550 and 350 pounds. It would seem that the most profitable amount to use is between 200 and 400 pounds, or, in round numbers, 300 pounds.

In the present experiments the sulphur was placed in a fertilizer machine and scattered in the open row. The farmers in this neighborhood bought the sulphur in large quantities, fully fifty barrels, and it was procured for about twenty dollars a ton or not far from a cent a pound. Taking the average of the three checks, 1,050 pounds, it gives 550 pounds of clean roots in favor of the plots receiving the 400 pounds of sulphur per acre, or 2,750 pounds for the whole acre. This is 110 baskets, counting 25 pounds to the basket, which, at 40 cents a basket, gives a net profit for the sulphur of $40 per acre.

Another experiment was carried out in 1896 upon the farm of Mr. Elmer Bradshaw, Mickleton, N. J., where the area was half that of the two above tests. The sulphur was mixed with a few times its own bulk of soil and a small quantity thrown in the hole where the plant was to be set. The amounts per acre were the same as in the other experiments and the results were equally favorable for sulphur.

Experiments with Sweet Potatoes the Present Year.

The Jersey field was continued in sweet potatoes this year, making the fourth successive crop upon the same land. The whole area was fertilized uniformly with 8 tons of stable manure and 500 pounds of complete fertilizer per acre, and additions of sulphur and kainit were made to five of the plots, as shown in the diagram of the field upon the adjoining page (Figure 39). These two substances were always added in the same amounts to any given plot, but the quantity

Vineyard.

Series I. Lime in 1895.	Slaked lime, 1,000 bushels. Stand, 95 per cent. *Yield.* *Clean.* *Marked* Yellow, 4 lbs. 10 lbs. Red, 9 " 7 "	Check. Stand, 98 per cent. *Yield.* *Clean.* *Marked.* Yellow, 2 lbs. 25 lbs. Red, 9 " 22 "	Lime, 500 bushels. Stand, 95 per cent. *Yield.* *Clean.* *Marked.* Yellow, 22 lbs. 24 lbs Red, 17 " 15 "	Lime 250 bushels; Sulphur, 625 pounds. Stand, 98 per cent. *Yield.* *Clean.* *Marked.* Yellow, 8 lbs. 33 lbs. Red, 22 " 25 "	Lime, 250 bushels. Stand, 90 per cent. *Yield.* *Clean.* *Marked.* Yellow, 17 lbs. 45 lbs. Red, 28 " 23 "
Series II. Flowers of sulphur in 1895.	Sulphur, 2,500 pounds. Stand, 97 per cent. *Yield.* *Clean.* *Marked.* Yellow, 87 lbs. 6 lbs. Red, 46 " 6 "	Lime, 500 bushels; Sulphur, 1,250 pounds. Stand, 94 per cent. *Yield.* *Clean.* *Marked.* Yellow, 2 lbs. 23 lbs. Red, 14 " 9 "	Sulphur, 1,250 pounds. Stand, 98 per cent. *Yield.* *Clean.* *Marked.* Yellow, 40 lbs. 15 lbs. Red, 27 " 10 "	Check. Stand, 95 per cent. *Yield.* *Clean.* *Marked.* Yellow, 1 lb. 30 lbs. Red, 11 lbs. 23 "	Sulphur, 625 pounds. Stand, 98 per cent. *Yield.* *Clean.* *Marked.* Yellow, 81 lbs. 29 lbs. Red, 35 " 25 "
Series III. Manure in 1895. Sulphur, kainit in 1897.	Sulphur, 16 pounds; Kainit, 16 pounds. (800 pounds per acre). Stand, 93 per cent *Yield.* *Clean.* *Marked.* Yellow, 45 lbs. 9 lbs. Red, 37 " 24 "	Check. Stand, 92 per cent. *Yield.* *Clean.* *Marked.* Yellow, 3 lbs. 16 lbs. Red, 6 " 27 "	Sulphur, 12 pounds; Kainit, 12 pounds. (600 pounds per acre). Stand, 90 per cent. *Yield.* *Clean.* *Marked.* Yellow, 30 lbs. 2 lbs. Red, 31 " 5 "	Manure, 5½ tons; Corrosive sublimate, 50 pounds. Stand, 96 per cent *Yield.* *Clean.* *Marked.* Yellow, 6 lbs. 24 lbs. Red, 7 " 41 "	Sulphur, 8 lbs.; Kainit, 8 lbs. (400 lbs. per acre). Stand, 98 per cent. *Yield.* *Clean.* *Marked.* Yellow, 44 lbs. 25 lbs. Red, 26 " 30 "
Series IV. Corrosive sublimate in 1895.	Corrosive sublimate, 200 pounds. Stand, 99 per cent. *Yield.* *Clean.* *Marked.* Yellow, 6 lbs. 35 lbs. Red, 12 " 45 "	Manure, 5½ tons; Corrosive sublimate, 100 pounds. Stand, 93 per cent. *Yield.* *Clean.* *Marked.* Yellow, 7 lbs. 19 lbs. Red, 12 " 37 "	Corrosive sublimate, 100 pounds. Stand, 90 per cent. *Yield.* *Clean.* *Marked.* Yellow, 2 lbs. 11 lbs. Red, 7 " 31 "	Check. Stand, 94 per cent. *Yield.* *Clean.* *Marked* Yellow, 3 lbs. 20 lbs. Red, 6 " 23 "	Corrosive sublimate, 50 pounds Stand, 98 per cent. *Yield.* *Clean.* *Marked.* Yellow, 8 lbs. 32 lbs. Red, 16 " 40 "
Series V. Kainit in 1895.	Kainit, 5,000 lbs. Stand, 100 per cent. *Yield.* *Clean.* *Marked.* Yellow, 6 lbs. 50 lbs. Red, 5 " 37 "	Check ('95–6). Sulphur, 4 pounds; Kainit, 4 pounds (200 pounds per acre). Stand, 95 per cent. *Yield.* *Clean.* *Marked.* Yellow, 28 lbs. 30 lbs. Red, 16 " 27 "	Kainit, 2,500 pounds. Stand, 98 per cent. *Yield.* *Clean.* *Marked.* Yellow, 5 lbs. 35 lbs. Red, 8 " 34 "	Kainit, 1,250 pounds; Sulphate of copper, 125 pounds. Stand, 98 per cent. *Yield.* *Clean.* *Marked.* Yellow, 5 lbs. 19 lbs. Red, 7 " 30 "	Kainit, 1,250 pounds. Stand, 98 per cent. *Yield.* *Clean.* *Marked.* Yellow, 11 lbs. 21 lbs Red, 12 " 32 "
Series VI. Sulphate of copper in 1895.	Sulphate of copper, 500 pounds Stand, 99 per cent. *Yield.* *Clean.* *Marked.* Yellow, 9 lbs. 52 lbs. Red, 16 " 25 "	Kainit, 2,500 pounds; Sulphate of copper, 250 pounds. Stand, 99 per cent *Yield.* *Clean.* *Marked.* Yellow, 10 lbs. 54 lbs. Red, 21 " 28 "	Sulphate of copper, 250 pounds. Stand, 96 per cent. *Yield.* *Clean.* *Marked.* Yellow, 5 lbs. 27 lbs Red, 11 " 26 "	Check ('95–6) Sulphur 6 pounds; Kainit, 6 pounds (300 pounds per acre). Stand. 92 per cent *Yield.* *Clean.* *Marked.* Yellow, 22 lbs. 10 lbs. Red, 21 " 15 "	Sulphate of copper, 125 pounds. Stand, 98 per cent. *Yield.* *Clean.* *Marked.* Yellow, 2 lbs. 15 lbs. Red, 8 " 23 "

Fig. 39.

Plan and Results of Field Experiments for Soil Rot of Sweet Potatoes at Cinnaminson in 1897.

varied with different plots. Thus, one plot had sulphur and kainit, each 800 pounds per acre, another 600 pounds of each, another 400 pounds, another 300 pounds, and the least amount was 200 pounds each of the fertilizer-fungicide.

Two varieties of sweet potatoes were used, namely, the "Yellow Nansemond" and the "Jersey Red," set in equal numbers and in alternating rows, there being four rows to each experiment plot.

The cultivation was done lengthwise of each series and therefore, there was necessarily some mixing of the substances used with the soil of plots adjoining upon the ends.

A visit was made to the field upon July 16th, when the general condition of the plants in each plot was noted, and it, combined with the appearance of vines at time of harvest, October 8th and 9th, is given in percentages under the term "stand," in the table. There was very little difference in the growth of the plants except upon the lime plots, where the vines were short, particularly so in the plot receiving the largest amount of lime.

In the table, Figure 39, the weights for both the yellow and red variety are given for each plot, and in the table given below the weights are placed in vertical columns for both varieties, and those where sulphur or sulphur and kainit were used are followed by the amounts per acre and the year of application.

	Yellow Nansemond.		Red Jersey.		
Plot	Clean.	Marked.	Clean.	Marked.	
1	4	10	9	7	
2	2	25	9	22	
3	22	24	17	15	
4	8	33	22	25	
5	17	45	28	23	
6	37	6	46	6	Sulphur, 1895, 2,500 pounds.
7	2	23	14	9	
8	40	15	27	10	Sulphur, 1895, 1,250 pounds.
9	1	30	11	23	
10	31	29	35	25	Sulphur, 1895, 625 pounds.
11	45	9	37	24	Sulphur and kainit, 1897, 800 pounds each.
12	3	16	6	27	
13	30	2	31	5	Sulphur and kainit, 1897, 600 pounds.
14	6	24	7	41	
15	44	25	26	30	Sulphur and kainit, 1897, 400 pounds.
16	6	35	12	45	
17	7	19	12	37	
18	2	11	7	31	
19	8	20	6	23	
20	8	32	16	40	
21	6	50	5	37	

Plot.	Yellow Nansemond. Clean.	Marked.	Red Jersey. Clean.	Marked.	
22	23	30	16	27	Sulphur and kainit, 1897, 200 pounds.
23	5	35	8	34	
24	5	19	7	30	
25	11	21	12	32	
26	9	52	16	25	
27	10	54	21	28	
28	5	27	11	26	
29	22	10	21	15	Sulphur and kainit, 1897, 300 pounds.
30	2	15	8	22	
	444	746	503	748	
Average.	14.8	24.9	16.8	24.9	

For the yellow variety, sulphur alone, applied two years before, gave an average for the three plots receiving it of 36 pounds of clean and 17 pounds of marked roots, as against 7.8 clean and 28.2 marked, as the average of the unsulphured plots. The five plots receiving sulphur in 1897 for the first time, and in connection with an equal weight of kainit, gave 32 pounds of clean to 15.2 pounds of marked roots, which, as compared with the results obtained upon the non-sulphured plots, shows a total gain of a third more roots, and between four and five times as much of roots free from any soil rot.

Turning now to the red variety, the figures are as follows:

Sulphur alone applied in 1895 gave an average for the three plots receiving it of 36 pounds clean and 13.7 pounds of marked roots as against 12 pounds clean and 23 pounds marked as the average of the unsulphured plots. The five plots receiving the sulphur with kainit in 1897 was 26.2 pounds of clean, and 20.2 pounds of marked roots. This shows a gain of one-third more roots, and between two and three times as many roots free from the soil rot.

The red variety gives a small percentage more of clean roots than the yellow, and a still smaller one of marked roots. In other words, the red sort yielded slightly better—1,250 pounds—than the yellow—1,190 pounds—and of this difference of 62 pounds, 59 pounds were free from marks of the soil rot. Figure 40 shows a badly-affected yellow potato at *a* and one of the red variety at *b*.

Taking the two varieties together and considering the sulphur and kainit plots in the order of the amount of the substances used and the results run as follows:

	Clean.	Marked.	Total.
800 pounds	82	33	115
600 "	61	7	68
400 "	70	55	125
300 "	43	25	68
200 "	39	57	96

The lack of a uniform increase of yield due to the additional amounts of kainit is to be explained by the unevenness in the field, there being a slight knoll that runs diagonally across the area and chances to give a poor spot to the 600-pound plot. Were this plot

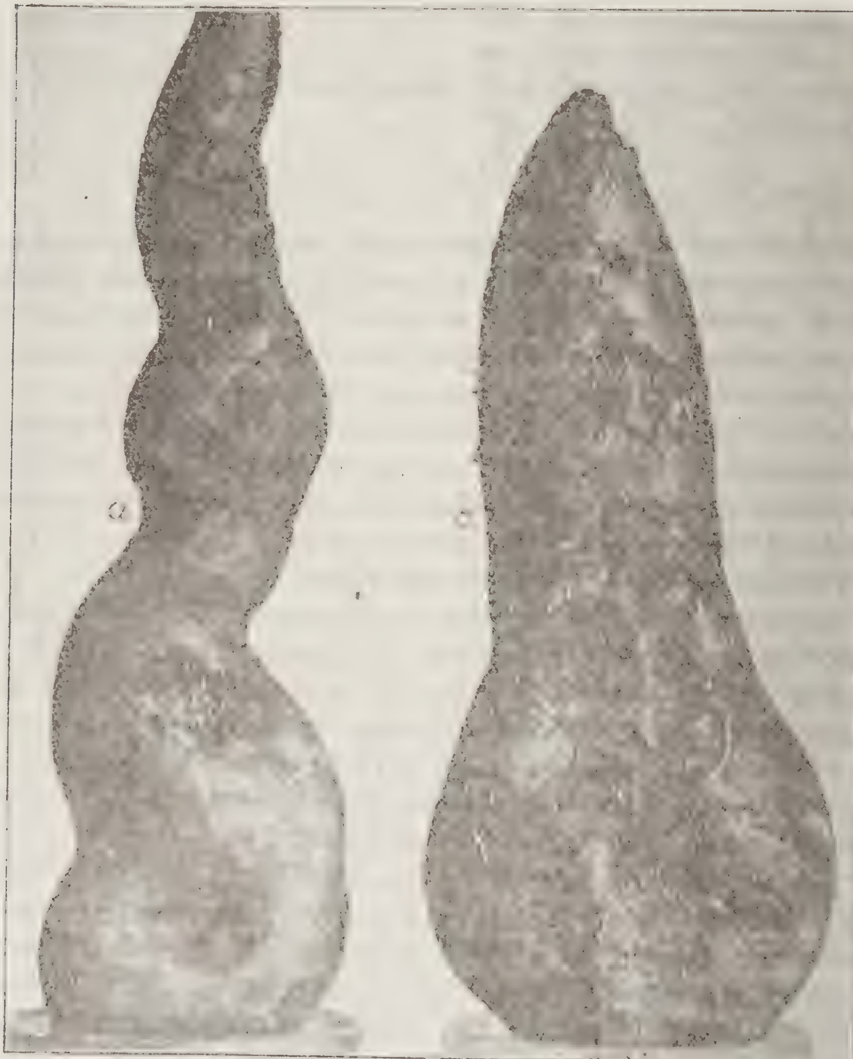


Fig. 40.

A Badly Diseased Yellow Sweet Potato is Shown at *a*, and one of the Red Variety at *b*.

up to the average in fertility it is not unlikely that the column of clean roots would show a uniform dropping from 82 to 39, due to the decreasing amount of sulphur.

The most striking feature of the experiment is the controlling

influence of the sulphur over the soil rot. There now remains only four untreated or check plots, the other two of the original six having been used the past season for a test of sulphur and kainit. These remaining four plots give the following results:

Clean roots 11, 12, 9 and 14 pounds, respectively, and marked roots 47, 53, 43 and 43 pounds, respectively, giving a total of 46 pounds of clean roots to 186 pounds marked. The other two plots that were checks until the present year, and the soil rot had a chance to increase because of the constant cropping of the land with sweet potatoes, gave 39 and 43 pounds of clean roots, respectively, and 57 and 25 pounds of marked roots, respectively, or a total of 82 pounds of clean roots to 82 pounds of marked, exactly half, when in the two previous years the yield was 84 pounds clean to 181 pounds of marked roots, and this was when the smaller amounts of the substances were used.

The fairest way to determine the effect of the sulphur and kainit is to select Series III., where the applications are the heaviest and the untreated plots lying between them are practically checks. The three treated plots give a total of 213 pounds clean and 95 pounds of marked roots, while the intervening plots gave 22 pounds of clean and 108 pounds of marked roots. By bringing these figures to terms of a single plot the result is 71 pounds clean and 31.6 pounds of marked roots for the treated plot and 7.3 pounds of clean roots and 36 pounds of marked roots for the untreated plot. In other words, there are nearly ten times as many pounds of perfectly clean roots upon the treated as upon the untreated ground.

Sweet Potatoes Upon the Experiment Area.

Belt 6, Plot III., Series II., was used for sweet potatoes, the leading point being to test this root-crop in its susceptibility to the scab fungus. There were five varieties grown, with weights of vines and roots as shown in the following table:

	Weight of Vines.	Weight of Roots.
Lovett's Yellow	44 pounds.	30 pounds.
Lovett's Red	11.25 "	17 "
Chinese	11.50 "	10.75 "
Vineless	20 "	23 "
Yellow Nansemond	20.50 "	21 "

The soil is not well adapted to the crop, and the roots were inferior. Nearly all the potatoes were badly scurfed, the worst being the "Vineless," next the "Chinese," next "Yellow Nansemond," next "Lovett's Red," and last "Lovett's Yellow."

There were no signs of the scab, and it would seem from this thorough test, for the neighboring belts produced very scabby Irish potatoes, that the sweet potato is not subject to the attack of *Oospora scabies* Thax. The same negative result was obtained last season, but then the crop was grown alongside, and not upon ground that had produced Irish potatoes that were very scabby.

EXPERIMENT IN SPRAYING FOR ASPARAGUS RUST.

During 1896 the outbreak of asparagus rust* (*Puccinia asparagi* DC.), was so severe that this Spring experiments were begun with fungicides, with the hope of finding a remedy for the rust. The four plots of asparagus in the experiment grounds were kindly offered by the Director for this work.

There was a difference in the soil treatment among the four plots, as recorded as follows in the Station Report for 1896:

"Plot 1—Manure at the rate of 18 tons per acre.

"Plots 2, 3 and 4—General fertilizer at the rate of 650 pounds per acre. Plot 3 received, November 2d, an even mixture of ground bone and muriate of potash at the rate of 300 pounds per acre. Plot 4 received, July 22d, nitrate of soda, 200 pounds per acre, and November 2d, bone and potash, 300 pounds per acre."

The first spraying was applied to Plot 1 June 2d. This plot was a trial ground for four different fungicides, namely, soda-Bordeaux, hydrate (check), Bordeaux and potash-Bordeaux, given in the order of their being used in the plot, beginning at the upper side of the field. A strip of three rows of plants running across all the varieties was sprayed with the soda-Bordeaux, and the next strip of equal size received the hydrate. The middle strip was the check, followed by the Bordeauxed strip, while potash-Bordeaux was sprayed upon the lowermost three rows of plants.

Plots 2, 3 and 4 were sprayed with Bordeaux mixture only, there being a middle strip of three rows of plants left as a check, as mentioned in Plot 1. The spraying upon these three plots began upon June 16th, the date of the second application upon Plot 1, and all plots were sprayed upon the same days throughout the course of the experiment.

All the plots received ten sprayings, and Plot 1, where the four fungicides were upon trial, one other, that being applied two weeks before the others received their first application.

*For an account of the sudden appearance of this enemy to asparagus, see the report of this department for 1896, pages 407–410.

The following are the dates of the sprayings and the amounts of Bordeaux used upon the three plots:

June 16th	18 gallons.	August 11th	24 gallons.
" 24th	18 "	" 24th	24 "
July 7th	18 "	September 7th	24 "
" 24th	22 "	" 20th	24 "
August 2d	22 "	October 4th and 5th	24 "
			218 "

The accompanying diagram shows the record of rustiness in terms of percentage for each plot. The average of the sprayed plants is 55.10 per cent., and that of the checks 74.8 per cent.

In Plot I. the average rustiness of all sprayed plants was	51
" " II. " " " " " " " "	51.5
" " III. " " " " " " " "	61.3
" " IV. " " " " " " " "	56.5
Grand average	55.10

In Plot I. the average of the check belts is	76
" " II. " " " " " " "	74.3
" " III. " " " " " " "	75.3
" " IV. " " " " " " "	73.6
Grand average	74.8

The gain in the sprayed over the unsprayed, taking the above average of averages as a basis, is 19.7.

Assuming the unsprayed to be 100 per cent., the sprayed would be 73.6, or, in other words, the fungicides reduce the rust more than one-quarter in round figures.

There is no difference in rustiness among the varieties except in one case, as the following percentages of the various rows show:

	Average.
Barr's Mammoth, 62, 60, 59, 60, 53, 70, 51, 64	60
Elmira, 60, 58, 56, 64, 65, 55, 58, 69, 74, 60, 66, 73	64
Columbian White, 64, 55, 64, 58, 66, 73, 65, 66	64
Palmetto, 32, 51, 33, 39, 50, 41, 50, 70, 53, 49, 49, 50	48
Conover's Colossal, 50, 66, 65, 58, 67, 76, 58, 72	64
Giant Brunswick, 65, 66, 61, 47, 64, 61, 57, 71	62
Moore's Crossbred, 67, 58, 70, 67	65.5
Giant Argent, 62, 60	61

It is seen from the above table the percentage of rust ranges from 48 to 65.5 per cent., but it is also to be observed that with the exception of the "Palmetto" the range is but slight, namely, in seven varieties only from 60 in "Barr's Mammoth" to 65.5 in the "Moore's

Crossbred." These figures are so close that for all practical purposes the susceptibility of all sorts except the "Palmetto" may be considered equal. As the last-named variety is best in each of the three rows of each of the four plots, it is quite safe to conclude that this sort is less injured than the other varieties alongside of which it grew. This result accords perfectly with those obtained by observations in the asparagus regions throughout the State where the "Palmetto" is grown in proximity to other varieties.

It was observed that the two sprayed strips that adjoined the check rows running through the middle were more rusted than the two outside strips. This may be due to no weakness of the fungicide and should therefore be here noted. The same increase in rust is recorded for the rows adjoining the check strip in the other three plots where Bordeaux only was used. This experiment therefore is so far a failure to test the comparative value of the four fungicides. Upon the face of the record, without regard to position and proximity to the check rows, the soda-Bordeaux stands first, potash-Bordeaux next, Bordeaux next and the hydrate last. Between the last three there is so little difference that they may all be considered as equally effective. The soda-Bordeaux had the advantage of being the farthest away from the check and from all other plants, it being upon the border of the field. Bordeaux or any other fungicide might have done as well in the same favored place.

Referring to the table of percentages by plots it is seen that there is a variation among the sprayed plants of 15.5 per cent., the lowest, 51 per cent., being upon Plot 1, and the highest, 60.3 per cent., upon Plot 3. In other words, there was somewhat less rust upon the plot (1) that received the manure only, and no ground bone and potash or nitrate of soda.

On the other hand, the unsprayed plants showed the greatest amount of rust upon the manured plot (1) and the least upon Plot 4, but as the range from highest (76 per cent.) to the lowest (73.4 per cent.) is only 2.4 per cent., and there is no agreement in the results between the sprayed and unsprayed plants, it is safe to conclude that manures and fertilizers played no appreciable part in the prevalence of rust.

The cost of the experiment in terms of days' labor and the fungicide at half a cent a gallon, was—

Ten sprayings, labor, 22 hours	$3 00
Fungicide, 218 gallons at half a cent a gallon	1 59
Total cost	$4 09

The area sprayed was practically three-sixteenths of an acre, including 576 plants, and gives the cost for a full acre, $21.76.

The applications were made with a knapsack pump, and therefore

Fig. 41.

A Sprayed Asparagus Stem is shown upon the right, and an Unsprayed upon the left.

were far more expensive than they would have been if the sprayings were made with horse-power. With the fungicide costing $5 in round figures per acre, and a machine that would spray two or more

rows at a time, it would be possible to reduce the cost to $10 per acre, or even less.

An opportunity offered for making a comparison between the staminate and pistillate plants, or more exactly of those that bore berries and those that did not. In Plot 1 the average rustiness for the berry-bearing sprayed plants is 41.1 per cent. as against 51 per cent. as the average for all plants. The percentage in the

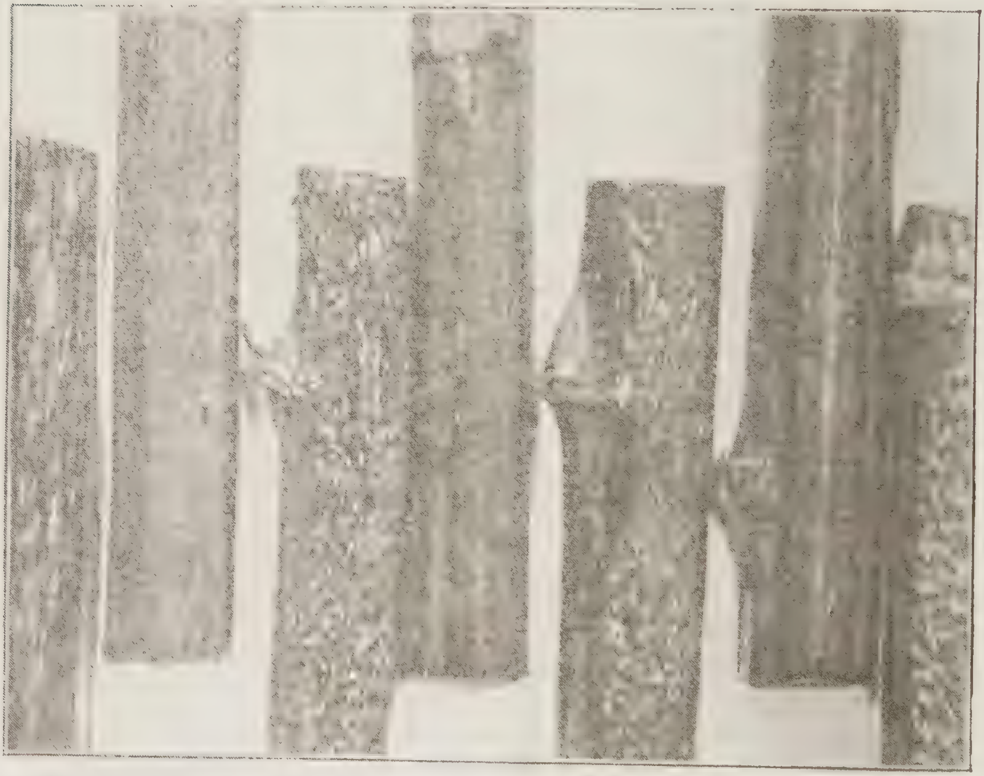


Fig. 42.
Asparagus Stems Showing Side of Infection.

unsprayed rows remains almost indentical (76.3 per cent.) with that for all plants, namely, 76 per cent.

Figure 41 gives the appearance of a sprayed and an unsprayed plant, the one upon the right being the sprayed, and was green, while the branch upon the left was lifeless. In Figure 42 is shown the appearance of the rust upon a close view. The alternate stems shown give the appearance of the opposite side of the stem—the side away from the source of infection.

EXPERIMENTS WITH PEAR BLIGHT.

Pear blight* is a contagious bacterial disease of the pear and allied fruit trees, caused by a very minute microbe discovered by Professor T. J. Burrell in 1879, and known to science as *Bacillus amylovorus* Bur. That this germ causes the disease is shown (1) by the immense number of micro-organisms in the freshly-injured twigs, (2) that these can be taken from an infected tree and cultivated in the laboratory of the bacteriologist and kept for months, (3) by inoculating a healthy tree with these pure germs the disease is produced, and (4) microbes are again found in abundance in the disease-inoculated tree of the same kind as were used in the experiment.

"Blight," Mr. Waite writes, "first appears in the spring upon the blossoms. About the time the tree is going out of blossom certain flower clusters turn black and dry up as if killed by frost. The blight spreads with great rapidity at blossom time, due to the fact that the germs multiply in the nectar of the blooms and are carried from one flower to another by bees and other insects which visit the blooms for the honey and pollen." If a few early blossoms are infected the insects will scatter the disease from tree to tree until it becomes an epidemic in the orchard. From the blossoms the disease may extend downward into the branches or run in from the lateral fruit spurs, so as to do a large amount of damage by girdling the limbs. The blight germs also enter through the tips of growing branches, and in the nursery this is the usual mode of infection. This form of disorder is called "twig blight," to distinguish it from "blossom blight;" but the two afflictions are results of different modes of attack of the same kind of germs.

Under conditions affecting the disease it may be stated in a general way that the trees most severely injured by blight are those which are vigorous, well cultivated and well fed. Warm and moist weather with frequent showers favors the disease, while dry, cool, sunny weather hinders it, and very dry weather may check it quite completely. With all its power for evil the microbe is a delicate organism, and soon perishes when not favorably situated for growth. Even when in the cambium layer, where the vital juices abound and are well protected, the germs frequently die out. This failure of the disease to continue is

* The following statements are drawn largely from the published reports of Mr. W. B. Waite, assistant in the Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture.

recognized in the sharp line between the living and dead bark in the so-called "body blight."

Mr. Waite is convinced that the pear blight germs remain alive through the winter in those regions of the tree where the blight was active at the close of the growing-season. "The germs keep alive along the advancing margin of the blighted area, and although their development is very slow it is continuous." In spring, when the trees are full of sap, the microbes that have outlived the winter start anew and extend their work. Next comes the new growth and the blossoms, and the gum that exudes from the blighted twigs attracts the insects, and the germs are carried to the blossoms and to the tips of shoots unfolding their tender leaves. The key to the situation seems to be in the living winter blight, and if it could all be destroyed there would be an end to the trouble.

Treatment for Pear Blight.

There are two general methods of treatment for the pear blight. First, put the tree in a condition to render it the least liable to attack. This means to so manure and cultivate that the tree will not grow rapidly. Thus the more a tree is fed the worse it will fare when attacked by the blight. Trees that are highly fertilized with nitrogenous manures are especially liable to blight. In short, over-stimulation with manures is to be avoided. Good tillage in the same way, while it makes a tree bear, also tends to increase the susceptibility to blight. Anything that retards the growth is beneficial, so far as the disease is concerned. The orchardist must stimulate by manures and culture sufficiently to give a good crop and shun that which will do more. Soil and situation will determine largely whether sod or cultivated soil may be best to resist the blight.

The second method is the extermination of the blight germs, which seems to be the only direct remedy. This is done by cutting out and burning all blighted portions of the trees. Every tree of the pome family, including the apple, crab-apple, pear, quince, mountain ash, service berry and hawthorns should be treated in the same manner. Particular attention should be paid to the active blight of late autumn, cutting it out and burning the branches before spring arrives. It is important to cut out the blight whenever seen, but all should be removed before the next growing-season begins.

To put the treatment in small compass, all blight should be removed as soon as seen, while the trees are growing. A thorough inspection needs to be made in the late fall for any branches showing blight. After these are cut out a sharp outlook should be kept for the disease in the orchard the next spring. In connection with pruning and burning the brush the trees should not be stimulated beyond what is required for a fair growth of wood and the production of a profitable crop.

In order to obtain further light upon the points above stated, an experiment has been planned to run five years. Mr. John M. Lippincott, of Moorestown, N. J., kindly placed a portion of his large Keiffer pear orchard at the service of the Experiment Station. In this orchard, set twelve years before and had blighted badly, a block of forty-nine trees was selected, standing in a square 7 x 7 and surrounded upon all sides by other trees of the orchard. While the orchard was quite even throughout, that portion was selected where the trees seemed most nearly alike in size and were blighted to an equal degree.

The plan of the experiment is given below:

	CULTIVATED ROWS.			Unchanged.	SODDED ROWS.		
	Barnyard manure.	Nothing.	Commerc'l fertilizers.		Barnyard manure.	Nothing	Commerc'l fertilizers
Row 1 {Winter (January) Pruning.}	1	2	3	4	5	6	7
Row 2 {Winter and Summer (January and July) Pruning.}	8	9	10	11	12	13	14
Row 3 {Summer (July) Pruning.}	15	16	17	18	19	20	21
Row 4—Check	22	23	24	25	26	27	28
Row 5 {Winter (January) Pruning.}	29	30	31	32	33	34	35
Row 6 {Winter and Summer (January and July) Pruning.}	36	37	38	39	40	41	42
Row 7 {Summer (July) Pruning.}	43	44	45	46	47	48	49

Fig. 43.

Plan of the Pear Orchard Experiment; the numbers represent the trees.

It will be seen from the above scheme that in the rows running in one direction (up and down) all the trees in a given row have the same soil treatment, while in the rows running at right angles to these the trees are pruned alike. In the soil treatment three rows are to be kept in sod during the five years the experiment is to run, while another three are to be under cultivation. The row lying between these two belts of three each is to be treated in the same manner as the other part of the orchard.

One row each of the sod and the cultivated belts receive barnyard manure in duplicate amounts, while the other two rows, similarly situated, are treated with commercial fertilizer. A row receiving no manure or fertilizer lies between each of these pairs of rows.

In the matter of pruning there are only two points of difference, namely, the July and the January removal of the blighted branches. Thus the upper row is pruned only in January of each year, the row next to this in both January and July, and the third in July only. The middle row of the seven receives no pruning, and rows 5, 6 and 7 are a duplicate of rows 1, 2 and 3 respectively.

The orchard had been under cultivation, and the ground preparation consisted in seeding down, upon the 15th day of October, 1896, the land under the right-hand three rows of trees looking from the northeast. A mixture of timothy and clover was used and the catch was fine and a rank growth of the mixture was upon the ground at the July pruning.

At the January pruning following a season of unusual blight, the trees were cut very severely, so much so that more than half the tops of some of the trees were removed and many of the large limbs were taken off bodily. In this winter pruning the guide in cutting was the dead tips and the blighted patches that could be easily seen upon the sides of the large twigs and branches that were removed.

In the July pruning only twigs showing the dead leafless tips of last year's destruction and the dead twigs with their blighted leaves attached that had been killed the present season, were removed.

The following record will show the nature of the prunings upon the four rows that were cut during July:

Row 1, winter-pruned only.
Row 2, winter and summer-pruned.

Tree No.	8	21 twigs removed.
" "	9	8 " "
" "	10	dying, but not from blight.
" "	11	3 twigs removed.
" "	12	9 " "
" "	13	4 " "
" "	14	12 " "

Row 3, summer-pruned only.

Tree No.	15	3	new and	40	old,	dead	twigs	removed.
" "	16	1	" "	19	"	"	"	"
" "	17	6	" "	85	"	"	"	"
" "	18	2	" "	52	"	"	"	"
" "	19	6	" "	43	"	"	"	"
" "	20	18	" "	103	"	"	"	"
" "	21	4	" "	18	"	"	"	"

Row 4, not pruned at all. In appearance same as row 3.
Row 5, winter-pruned only. There was but little blight.
Row 6, winter and summer-pruned.

Tree No.	36	0	new and	1	old,	dead	twigs	removed.
" "	37	0	" "	3	"	"	"	"
" "	38	0	" "	9	"	"	"	"
" "	39	4	" "	10	"	"	"	"
" "	40	5	" "	6	"	"	"	"
" "	41	4	" "	14	"	"	"	"
" "	42	8	" "	9	"	"	"	"

Row 7, summer-pruned only.

Tree No.	43	0	new and	10	old,	dead	twigs	removed.
" "	44	1	" "	24	"	"	"	"
" "	45	3	" "	15	"	"	"	"
" "	46	1	" "	14	"	"	"	"
" "	47	dying, but not from blight.						
" "	48	6	new and	55	old,	dead	twigs	removed.
" "	49	4	" "	17	"	"	"	"

In the summer pruning the trees were not cut nearly so severely as in the winter pruning, because the green, healthy foliage served as a guide, and not the blighted patches upon the limbs. The average length of the summer prunings was not far from three feet, while that of the winter was perhaps three times that. Upon the other

hand, while the cutting back is not so severe, the summer pruning comes at a busy time of the year, and the work among the trees, at best, knocks off more or less fruit. There are advantages in favor of both summer and winter pruning.

One point of importance that needs to be remarked is the lack of increase of freshly-blighted twigs in the trees pruned only in summer. Row 2, winter and summer-pruned had 57 newly-blighted twigs to 40 upon row 3 with summer pruning only. Row 6, pruned in both winter and summer, had 21 newly-blighted twigs to 14 upon row 7 summer-pruned only. In short, the two rows with the blighted twigs removed in January, had 78 newly-blighted twigs in July, while those trees upon which the blighted twigs were left in January, had only 54 newly-blighted twigs in July.

Without this estimate of the twigs the fact was evident to everyone who looked at the orchard that the winter pruning did not diminish the twig blight, or, in other words, the leaving of the blighted twigs upon the tree did not increase the number of badly-blighted twigs. It was a rare instance that the blight spread from an old injured twig through the wood and caused a fresh blight of adjacent leaves. Usually a freshly-blighted twig was not directly connected with one that was previously blighted.

The crop was harvested in October, with the results in terms of baskets holding five-eighths of a bushel, as shown in the following diagram:

Row.								Total.	Avge.
1	7	8	2.5	1.5	8	3.5	4	34.5	4.9
2	5	6.5	5.5	....	5.5	3	3.5	29	4.8
3	5	5	9	3	5	3.5	4.5	35	5
4	3.5	6.5	5.5	2.5	4	4.5	4.5	31	4.4
5	8.5	3	2	5	5.5	5	5	33.5	4.8
6	2	2	6	4.5	3	6.5	2.5	26.5	3.8
7	5	5.25	3	4.5	....	6.5	5.25	29 5	4.9

One tree in row 2 and another in row 7 are dead, and therefore the averages show the results for each tree.

From these averages it will be seen that the variation is not great. The lowest average is 3.8 baskets per tree in row 6, where the trees received both winter and summer pruning, and the highest is 5 baskets in row 3, where the trees received summer pruning only.

By combining the averages of the two rows receiving the same treatment the table stands as follows:

Winter pruning only	4.9 and 4.8—4.85	baskets.
Winter and summer pruning	4.8 " 3.8—4.30	"
Summer pruning only	5 " 4.9—4.95	"
No pruning	4.4	"

The average of all the pruned trees is 4.70 baskets.

It is seen that the difference is but small and is in favor of the pruned trees.

Mr. Lippincott remarked, in a letter concerning the harvest, that "The rows of trees that were pruned in winter were cut the heaviest, leaving less wood to make a crop, but the pears were much larger and made about as many baskets as elsewhere. * * * I saw very little difference in the general appearance of the fruit other than the size."

The coming spring the manure and fertilizer feature of the experiment will begin with the rows thus treated, running at right angles to those governing the character of the pruning.

GREENHOUSE EXPERIMENTS WITH VIOLETS.

During the past eight years since this Department in the Experiment Station was established, there have been frequent calls for information concerning the diseases of cultivated violets. From time to time microscopic examinations have been made of sick violet plants sent to the Station from a considerable number of floriculturists throughout the State and elsewhere.

In the winter of 1893–4 a series of spraying experiments with violets in a greenhouse was carried out at a large commercial establishment in the State. Spraying experiments were made the same winter upon violets under sash.

Box experiments were also made with violets the same season, and the results are recorded in the Annual Report of the Experiment Station for 1894. The following are the conclusions drawn at that time:

"Of the three fungicides used, namely, Bordeaux, cupram and corrosive sublimate, Bordeaux is the only one that has given beneficial results. Diseased stock, after being sprayed for two months with this fungicide, although not free from leaf spot, was infested to a less degree than the unsprayed.

"Half-strength Bordeaux applied once in ten days to violets under glass may have a tendency to retard the time of blooming, but if a

quarter-strength solution is used it is believed that this objection may be overcome, and the weaker solution will prove equally effective as a fungicide,"

The leading fungous troubles of violets as determined by a microscopic examination of diseased specimens are the leaf spot (*Cercospora Violæ* Sacc.) and a second form of leaf spot (*Phyllosticta Violæ* Desm.), that to the naked eye produces spots in the leaf not easily distinguished from those following the injury of the Cercospora. The *Ascohyta Violæ* Sacc. is less common and induces spots like the Cercospora. The *Marsonia Violæ* Sacc. is not infrequently met with, and produces blotches upon the violet leaves similar to those that form when the foliage is attacked by a fifth fungus, the *Glœosporium Violæ* B. & Br. Closely related to the last is another anthracnose, due to a Colletotrichum yet undescribed. Several other fungi are met with occasionally as a mildew (*Peronospora Violæ* D.By.) and *Zygodesmus albidus* E. & Hals., producing a white mould upon the foliage.

One of the leading troubles of violets is due to nematodes, treated of under "root galls," with engravings upon pages 384, 385 of the report for 1892, and another is a dropsical tendency in the foliage, due to unfavorable conditions under which the plants have been placed, and is considered with an engraving upon pages 385, 386 of the report for 1894.

No space needs to be taken here to argue for the importance of beginning a series of experiments in the cultivation of violets. Of all the crops now grown under glass, there is none that is more uncertain than violets and about which there is greater need of information.

During the winter of 1896–7 a small greenhouse was secured for violet experiments, and the following plan was carried out:

Plants of the Marie Louise variety were purchased of nine different commercial growers who were carrying advertisements of violet plants in the leading florists' journals. It was the intention to get the plants from as wide a territory as possible. Four of the nine lots were pot-grown and the remaining five were grown in the open field. All but one proved true to name, the exception being the Lady Campbell.

The experiment called for fifty-two boxes two feet square and six inches deep, arranged in thirteen series and four boxes in each series, as shown in the following plan:

	Box. A.	Box. B.	Box. C.	Box. D.
Series I.—*Depths.*				
Ordinary soil, depth in box	6 in.	4 in.	8 in.	2 in.
Series II.—*Fineness**	Coarse.	Medium.	Fine.	Finest.
Ordinary soil, sieved.				
Series III.—*Mixture*	¼ sand.	⅜ sand.	½ sand.	⅝ sand.
Ordinary soil, plus sand.				
Series IV.—*Check*	a.	b.	c.	d.
Ordinary soil, depth five inches.				
Series V.—*Drainage*	1 in. earth at top.	2 inches.	3 inches.	4 inches.
Ordinary soil, plus broken stone.†				
Series VI.—*Mulching*	½ in. soot.	Wire gauze.	Paper.	Sand.
Ordinary soil.				
Series VII.—*Watering* (surface)	⅓ normal.	⅔ normal.	4/3 normal.	5/3 normal.
Series VIII.—*Sub-irrigation*	⅓ normal.	⅔ normal.	4/3 normal.	5/3 normal.
Series IX.—*Plant-food* (Albert concentrated)‡	a 1.	b ⅓.	c ½.	d ¼.
Series X.—*Manure* (cow)	⅛ of total.	⅓ total.	¼ total.	½ total.
Series XI.—*Aeration* (charcoal)	⅛ of total.	⅓ total.	¼ total.	½ total.
Series XII.—*Spraying*	Soda-Bord.	Bordeaux.	Pot.-Bord.	Am.-Bord.
Series XIII.—*Soil fungicides*	Bord. 2-400.	Sulph. 1-400.	Cor. Sub. 1-4,000.	Lime. 1-100.

Each box received nine plants and they were always set in the same order throughout the thirteen series. The lots of plants were numbered from one to nine, in the order of their arrival, and arranged in the boxes according to those numbers, as shown in the following diagram:

No. 1.	No. 2.	No. 3.
No. 4.	No. 5.	No. 6.
No. 7.	No. 8.	No. 9.

The plants were bought through a private individual, in the open market, to avoid any chance of favoritism.

The localities represented by the plants, given by States, and the price paid per hundred, are as follows:

No. 1—Connecticut	$4 00	per	hundred	potted plants.
No. 2—New Jersey	2.50	"	"	potted plants.
No. 3—Pennsylvania	3.00	"	"	potted plants.
No. 4—Kentucky	2.50	"	"	field-grown.
No. 5—Michigan	5.00	"	"	field-grown.
No. 6—Illinois	4.00	"	"	field-grown.
No. 7—New York	6.00	"	"	field-grown.
No. 8—New York	3.00	"	"	field-grown.
No. 9—Michigan	2.50	"	"	potted plants.

* Under Fineness the so-called "coarse" was the ordinary soil left after sieving out the fine through a sieve with half-inch mesh, the "medium" soil was all that went through the half-inch mesh, and the "fine" that which remained behind after sieving the "medium" through sieve with a quarter-inch mesh to get the "finest."

† The broken stone was that used for the finishing layer of ordinary street Macadam.

‡ The concentrated Albert food was used one ounce to eight gallons, and the amounts of this fertilizer solution were the same as for Series VII., which was the check to this series.

The Connecticut-grown violets occupy the further left-hand corner of each box; No. 5, from Michigan, chanced to come in the center, while No. 7, one of the two lots from New York, the nearer left-hand, and No. 9, the second Michigan lot, the nearer right-hand corner of each box. It was No. 4 that failed to be true to name, so that in this case there was an unintentional variety test secured when the hope was to make only a trial of plants of the same sort, but grown in widely-separated localities.

The boxes were arranged in two parallel rows upon each side of the passageway in the middle of a greenhouse 38 feet long and 10 feet wide, running southwest and northeast. In order to secure as nearly as possible the same conditions for all the boxes, they were changed each week in the following manner: The four boxes in each series formed a square, and the set of four were revolved, so to speak, one-quarter round each week, that is, box A took B's place and B C's, and so on, so that at the end of four weeks box D, for example, was returned to its former place after making a circuit.

For twenty weeks, beginning November 10th and ending March 30th, a weekly record of the condition of each plant was kept. Fifty was assumed as the maximum for a first-class plant, and if a plant fell below this in its condition it was marked 49 or less, as the case demanded; and upon the other hand when a plant was at the outset or became afterward an extra it was scored with some number above 50.

From the record given in Figure 44, it is seen that the total output of blooms, while small, is greatest for No. 5, which possibly had a somewhat better chance than any other set because occupying the center of each box. However, the space was ample, and very little credit needs to be given to the conditions. This, as previously stated, was a lot from Michigan, were field-grown, and the plants were of good size at the outset, and cost $5 per hundred.

The second-best bloom-producers under all the various conditions of the thirteen series was No. 7, from a large propagator in the violet-growing district along the Hudson river, and while not as large as No. 5, were higher in price, namely, $6 per hundred. The above two numbers, 5 and 7, were the two highest-priced plants, and the results speak in favor of getting good stock from which to grow blooms.

The poorest three lots were Nos. 1, 2 and 3, the second being somewhat worse than the first, which in turn was led by No. 3. These were all pot-grown plants of low price, and the poorest of all were

the ones that had been grown in our State, and were bought for $2.50 per hundred. The only other pot-grown lot was No. 9, which was the second set obtained from Michigan. These plants cost $2.50 per hundred, and ranked third in the number of blooms produced. The average number of blooms from the pot-grown plants is 95.5, and from the field-grown 247.6, or nearly five times as many for the latter as for the former, which is a strong showing for plants grown in the field.

	Depths.	Fineness.	Sand.	Check.	Drainage.	Mulching.	Watering.	Sub-irrigation.	Plant-food.	Manure.	Aeration.	Spraying.	Soil Fungicides.	Totals.	Rank.
Series.....	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII		
Plant 1...	......	19	3	3	2	....	....	....	8	9	2	1	....	47	8
Plant 2...	......	15	3	....	....	5	....	....	4	2	....	....	....	29	9
Plant 3...	7	5	10	2	12	1	....	8	14	27	7	1	3	97	7
Plant 4...	30	36	28	30	31	21	38	16	38	12	21	2	3	115	6
Plant 5...	20	68	26	42	6	5	19	10	27	105	15	2	4	349	1
Plant 6...	6	50	4	21	13	5	11	6	14	56	4	3	4	187	5
Plant 7...	22	60	14	28	23	20	15	30	32	33	22	3	6	308	2
Plant 8...	19	36	18	25	22	8	3	9	45	65	11	2	16	279	4
Plant 9...	25	44	35	20	28	7	8	7	30	75	18	2	8	297	3
Total.....	129	333	141	171	132	72	94	86	216	384	100	15	39	...	...
Rank.....	7	2	5	4	6	11	9	10	3	1	8	13	12	....	....

Fig. 44.

Plan and Results of the Violet Experiment.

In glancing at the table of totals in the vertical lines it is seen that the greatest number of blooms, 384, was obtained from the manure series, followed closely (333 blooms) by the series where fineness of the soil was the point at issue. The third-best series (216 blooms) was the one receiving the Albert plant-food. Five of the series are below, and the three above mentioned are all much ahead of the check with its 171 blooms.

The poorest series was the one where the spraying experiments

were attempted. The various substances proved too strong for the tender foliage of the violet, and it was so badly injured that the plants became practically worthless. The same is true of Series XII., where soil fungicides were employed, these substances having been used in too great strength. Next to these last two series where the plants were injured by chemicals comes Series IV., in which mulchings were used. Sub-irrigation, Series VIII., follows closely with somewhat better results, there being only a slight difference between this and Series 7, where the same amounts of water were added to the surface. The aeration series, where charcoal was mixed with the soil, gave poor results, there being an even hundred blooms to 171 in the check. Depths of soil, drainage with a sublayer of broken stone and the sand series take up a middle place in the list of averages.

By taking the three best lots of plants, namely, Nos. 5, 7 and 9, and studying them in all series where the total blooms of the series is more than a hundred, that is, throw out six and retain seven of the series, the following table is constructed:

	Series I.	II.	III.	IV.	V.	IX.	X.
Lot 5	20	68	26	42	6	27	105
" 7	22	60	14	28	23	32	33
" 9	25	44	35	20	23	30	75
Total	67	172	75	90	52	89	213

This set is nearly parallel with the whole series and includes the most promising plants and conditions.

In Series I., where depth of soil was tested, it is found from the record-book, where each individual plant is credited with its output of blooms week by week, that the results are as follows:

	Lot 5.	Lot 7.	Lot 9.	Total.	Average.
Box A, soil 6 inches	8	9	6	23	7.6
" B, " 4 "	8	2	10	20	6.6
" C, " 3 "	4	8	7	19	6.3
" D, " 2 "	...	3	2	5	1.6
Total	20	22	25	67	

The average of these three lots of plants in the whole four boxes of the check series (No. 4) is 7.7, and is, therefore, a slight gain over the additional inch of soil in box A. The depth of five inches chosen for the normal throughout the whole experiment is seen to be practically the best.

Series II., where the mechanical condition of the soil was considered, gave quite unexpected results. An abbreviated table for this series, comparable with that just given for Series I., is as follows:

	Lot 5.	Lot 7.	Lot 9.	Total.	Average.
Box A, coarse soil	31	27	6	64	21.3
" B, medium soil	27	8	18	53	17.6
" C, fine soil	4	11	...	15	5
" D, finest soil	6	14	20	40	13.3
Total	68	60	44	172	

From this it is gathered that the coarsest soil, namely, that left after sieving out all that could be removed with a sieve with a half-inch mesh, gave far the best results, and that the next coarsest soil was next best, and the finest soil ran much higher than the one next coarser.

Series III., where sand was added in varying amounts to the soil, the table stands as follows:

	Lot 5.	Lot 7.	Lot 9.	Total.	Average.
Box A, one-fifth sand	11	5	3	19	6.1
" B, two-fifths sand	10	9	3	22	4.3
" C, three-fifths sand	3	...	8	11	3.6
" D, four-fifths sand	2	6	21	29	9.6
Total	26	20	35	81	

It is seen that there is only a small number of blooms, and, with the exception of a single plant in box D, there is not much difference among the amounts used.

Series IV. is the check, and for comparison a corresponding table is constructed for it:

	Lot 5.	Lot 7.	Lot 9.	Total.	Average.
Box A, plain soil, 5 inches	11	11	3	25	8.1
" B, " " " "	15	...	2	17	5.6
" C, " " " "	7	11	5	23	9
" D, " " " "	9	6	10	25	8.1
Total	42	28	20	83	

Series V. contains boxes with broken stone in varying depths in the bottom and gave the following results:

	Lot 5.	Lot 7.	Lot 9.	Total.	Average.
Box A, 1 inch of earth	5	13	6	24	8
" B, 2 " " "	...	5	1	6	2
" C, 3 " " "	...	5	7	12	4
" D, 4 " " "	1	...	9	10	3.3
Total	6	23	23	52	

The plants with one inch of earth did better than those where the soil was deeper and exceeded those of the check plants, but the total blooms are only half those in the four check boxes. It would seem, therefore, that the use of rock bottom for drainage is useless.

In Series IX. the Albert concentrated plant-food was employed in varying strengths with the following results:

	Lot 5.	Lot 7.	Lot 9.	Total.	Average.
Box A, full amount	...	3	3	6	2
" B, half amount	9	13	12	39	13
" C, quarter amount	10	7	13	30	10
" D, fifth amount	8	4	2	14	4.6
Total	27	32	30	89	

The best results were obtained where the half amount of the food was employed, followed closely by the quarter-strength. The full amount gave very poor results.

Series X. received the manure and gave the following for the table for three of the lots:

	Lot 5.	Lot 7.	Lot 9.	Total.	Average.
Box A, one-half cow manure	22	9	35	66	22
" B, one-third cow manure	22	15	13	50	16.6
" C, one-quarter cow manure	14	5	17	36	12
" D, one-fifth cow manure	47	14	10	71	23.6
Total	105	43	75	223	

It is seen that there was one unusual plant in lot 5, box D, that did better than all others, and this makes a high average for the box containing only one-fifth part of cow manure. Aside from this plant, the totals would run gradually less as the manure decreased from a half to a fifth amount.

The greatly-increased number of blooms in the manured series confirms the opinion held at the outset, that the earth chosen for the experiments was not rich enough for the best product of bloom.

In connection with this experiment there was a parallel one carried out, using six-inch pots instead of boxes, and using only plants of the same lot, namely, those of No. 9, and giving but a single plant to each plot. The results were so nearly the same as those above recorded for the boxes that no further space will be taken here to give any details. From this lot of plants there was procured by cuttings the stock for an experiment that was started in November with various soil treatments for violets in pots.

In order to further test the relative value of the nine lots of plants a portion of a hotbed was set with them, the nine rows of five plants each running crosswise and containing the lots from one to nine, beginning at the higher end of the sash. Under these conditions, as nearly as possible, common to all lots, there were the same differences in vigor and blooming of the plants as shown in the results of the box experiments. A photograph of the frame was taken (Figure 45), which shows the condition of the plants at the height of their blooming,

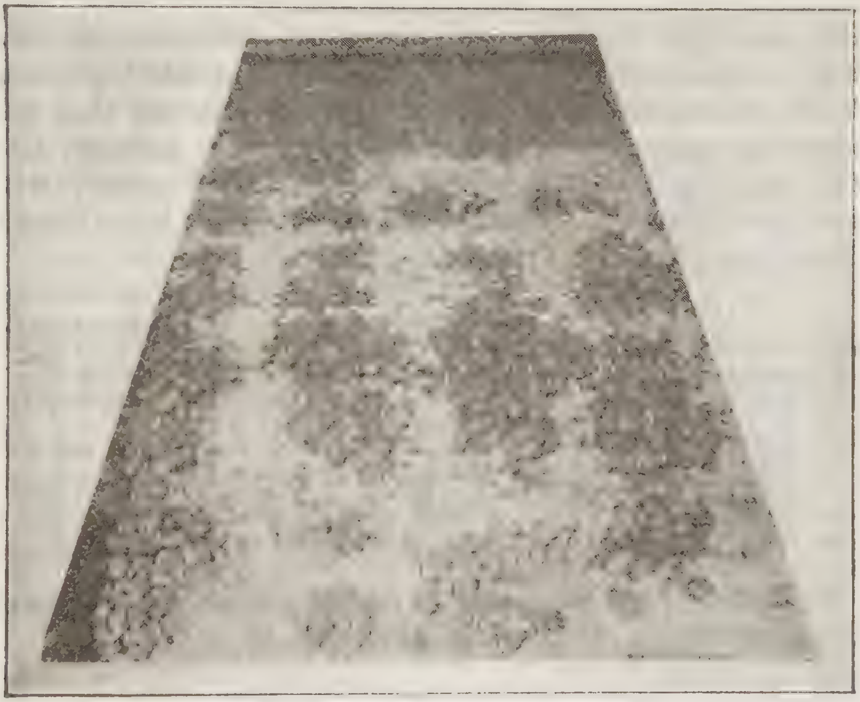


Fig. 45.
View of Violets in Cold Frame.

and it is seen that the three upper lots are very poor and the best plants are in the middle row, namely, No. 5.

Upon the removal of the violets from the cold frame April 5th, and washing the roots of all the plants, it was found under conditions as nearly the same as possible to supply, that there were great differences in the results. Nos. 5 and 6 were the largest, while Nos. 1, 2 and 3 were very poor. No. 4 was "Lady Campbell," and while small, is not comparable with the other eight representatives of the "Marie Louise." Nos. 7, 8, and 9 were medium-sized plants. The roots of

Nos. 3, 4 and 6 were badly galled; Nos. 1, 2, 7, 8 and 9 somewhat galled, and only those of No. 5 were free from galls. This test as being parallel in results with that in the greenhouse, leads to the opinion that the plants of all except No. 5 were more or less galled when set out, and the spread of the trouble from plant to plant in the cold frame is not rapid.

There was no leaf spot or other foliage disease that interfered with the growth of the plants, but from their behavior there were strong suspicions of root trouble, presumably the nematode root galls. Therefore, upon April 1st, at the conclusion of the experiment, the plants in all boxes marked "C." and "D.," and therefore including one-half of the total number, were removed from the earth and their roots washed and examined. The results are given in the following table, "C." standing for clean; "D.," doubtful; "G.," galled; "B.," badly galled, and "V. B." very badly galled. These letters stand in place of the plants in the tabulation:

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.
Number 1....	D. D.	V. B.	D. D.	D. G.	D. G.	G.	D. D.	D.	D. C.	D. C.	G. G.	D.	D.
" 2....	D. G.	G. G.	D. D.	G. G.	D. D.	G. C.	D.	D G.	C. C.	G. C.	G. G.	G. G.	G.
" 3....	B. B.	....	C. G.	D. D.	G. D.	G B.	V. B. D.	G. B.	G. G.	D. G.	G. G.	D. G.	G.
" 4....	G.	D. V. B.	G.	D. G.	G. D.	G. D.	....	....	D. V. B.	D.	B.	V. B.	G.
" 5....	D. D.	C.	C. C.	D. C.	D.	C. C.	D. C.	G. D.	C. D.	C. G.	C. C.	D. D.	C.
" 6....	V. B.	V. B.	V. B.	V. B.	B.	V. B.	C.	B.	V. B.	G.	G. B.	D.	D.
" 7....	V. B.	D.	C. G.	G. G.	D. D.	D. D.	D. C.	G. G.	D.	D.	G. G.	D. D.	D.
" 8....	....	D. G.	C.	G. G.	....	G. G.	D.	G. G.	D.	D. D.	G. G.	G.	C.
" 9....	G. G.	V. B.	C. G.	V. B.	G. G.	G. D.	B. C.	G.	D. D.	V. B.	G. G.	D. B.	V. B.

In another form the results of this inspection are given below, where the different grades are broughr together:

	Clean.	Doubtful.	Galled.	Badly galled.	Very badly galled.	Total.
Number 1..................	2	13	5	1	...	21
" 2..................	4	8	11	...	...	23
" 3..................	1	6	9	4	1	21
" 4..................	...	6	7	2	3	18
" 5..................	11	9	2	..	...	22
" 6..................	1	2	4	3	11	21
" 7..................	2	11	5	...	2	20
" 8..................	2	6	8	...	...	16
" 9..................	1	4	8	2	5	20

The rank in order of least galling runs as follows: Lots 5, 1, 7, 8, 2, 4, 3, 9, 6; that is, lot 5 contained the plants with the least amount of root gall, and its next neighbor, No. 6, exceeded all others in the amount of this trouble.

There is no close relation between the presence of root gall and the production of blooms, as the following lines show:

Lots....................	5	1	7	8	2	4	3	9	6
Number of blooms..	349	47	308	279	29	115	97	297	187

If, however, the total of the first four lots is compared with that of the last four, the figures stand as follows: The four least galled gave 983 blooms, while the four most galled yielded 696 blooms, or nearly a third less. It is something to be remarked, however, that the lot (No. 9) that was next to the worst in the amount of galls stood next to the first in yield of blooms. It is also noted that this lot of plants is the one from which plants were propagated for further experiments.

The flowers from the manure and plant-food boxes, picked upon February 17th, being the largest and finest, were submitted to five different persons, all of whom pronounced them the sweetest, and those from the plant-food the next sweetest of all. Upon March 3d, the flowers from each series were kept separate, and those from the drainage boxes were found of a somewhat deeper color. Upon March 10th, it was observed that the blooms produced in the sand series were of a lighter color and had shorter stems than elsewhere, the manure boxes having flowers with the opposite qualities. Upon March 17th, it was noted that a dry soil tends to give lighter-colored blossoms than a well-watered one.

Field Experiments with Violets.

It will be recalled that only a half of all the plants were examined for root gall upon April 1st. The remaining half, namely, boxes A and B of each series, were left in place until May 4th, when the best plants from lots 5 and 6 were selected for field experiments. These two lots were chosen because the former was the leader in output of blooms, and contained almost no root galls, while No. 6 was poor in flower production, and had the largest amount of galls upon the roots.

The easternmost row in the ornamental series was set to violets upon May 4th, 1896, the upper half with plants from lot No. 5 in the greenhouse boxes, and the lower half received plants from lot No. 6.

The upper half of the row was divided into five sections of 13.8 feet each, and each section received twelve plants. The order for soil

treatment was as follows for this half row: (1) lime, (2) sulphur, (3) check, (4) corrosive sublimate, (5) kainit. These substances were taken from belts elsewhere in the Experiment Area where they were in use. Thus the lime was from Turnip Series, Plot IV., belt 2, 600 bushels per acre; the sulphur from the Potato Series, Plot IV., belt 2, 300 pounds per acre; the corrosive sublimate from the Potato Series, Plot I., belt 3, 60 pounds per acre, and the kainit from the Potato Series, Plot III., belt 3, 1,200 pounds per acre.

The lower half, set with plant No. 6, had the order of the substances reversed, otherwise everything was the same as for the upper half; that is, the treatment was as follows down the row: Kainit, corrosive sublimate, check, sulphur and lime.

The amount of treated soil used for each plant was about one pound, placed around the plants, that were set in a hole four inches deep and three inches across.

All the plants received the same care, there being no spraying or other treatment throughout the season, and upon October 23d were lifted, the roots thoroughly washed and examined for root galls, with the following results:

Lot No. 5.	Lime.	Sulphur.	Check.	Corrosive sublimate.	Kainit.
Number of plants	5	2	8	5	7
Number galled	...	...	...	...	...
Number clean	5	2	8	5	7
Lot No. 6.					
Number of plants	4	5	9	2	6
Number galled	3	4	6	2	5
Number clean	1	1	3	...	1

The time of setting out these plants was quickly followed by a hot, dry spell, which had much to do with the reduction of the number of plants that lived through the season.

Nine plants were made out of each lot, except in No. 5, sulphur where there were only three, and in corrosive sublimate, No. 6, where there are only two plants.

These twelve lots were placed separately in the boxes used the season before for violets, the soil being of good quality, purchased for the purpose. There was no difference in soil or other treatment provided for these twelve boxes, the intention being to note the results upon the winter plants of the varying summer conditions of soil that were given them.

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